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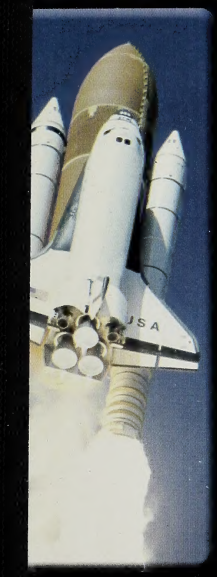

SCIENCE 24

MODULE 4 • SAFETY IN TRANSPORTATION

Learning Technologies Branch

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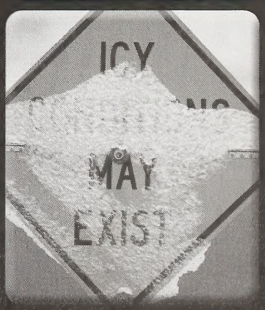
SCIENCE 24

MODULE 4 ■ SAFETY IN TRANSPORTATION



Science 24
Module 4: Safety in Transportation
Student Module Booklet
Learning Technologies Branch
ISBN 0-7741-2595-0

The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	

You may find the following Internet sites useful:

- Alberta Learning, **http://www.learning.gov.ab.ca**
- Learning Technologies Branch, **http://www.learning.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.learning.gov.ab.ca**

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Welcome to SCIENCE 24

Module Four

Science 24 contains four modules.
You should work through the modules in order (from 1 to 4) because concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.

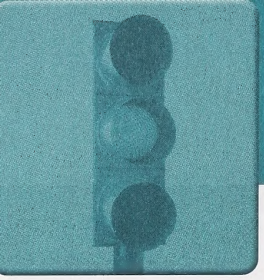
Module 1 contains general information about the course, course components, resources, assessment and feedback, and visual cues. If you do not have access to Module 1, contact your teacher to obtain this important information.

MODULE 1
- MATTER AND CHEMICAL CHANGE -

MODULE 2
- ENERGY TRANSFORMATIONS -

MODULE 3
- DISEASE DEFENCE AND HUMAN HEALTH -

MODULE 4
- SAFETY IN TRANSPORTATION -



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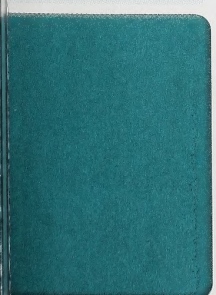
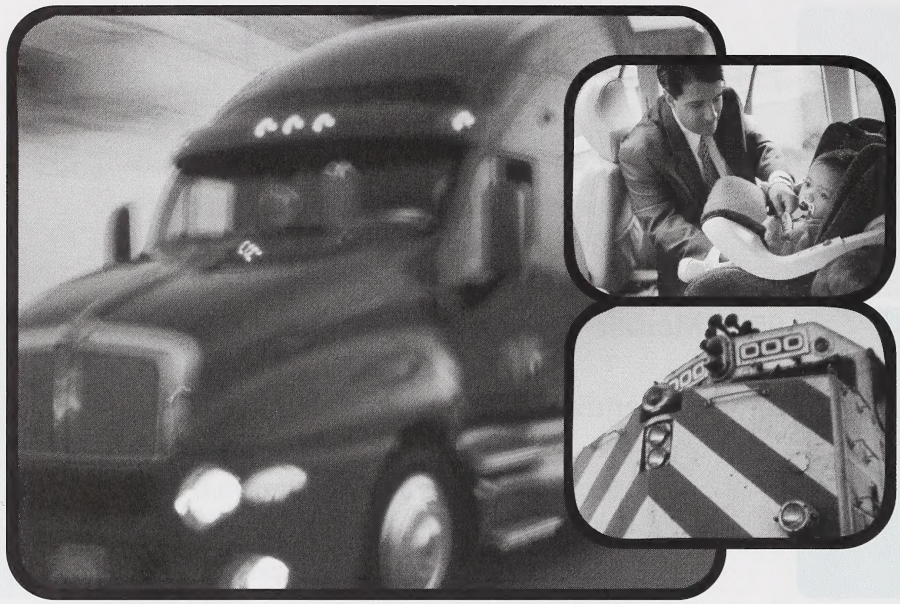
T1 **Ticker Tape for Graphing Motion**

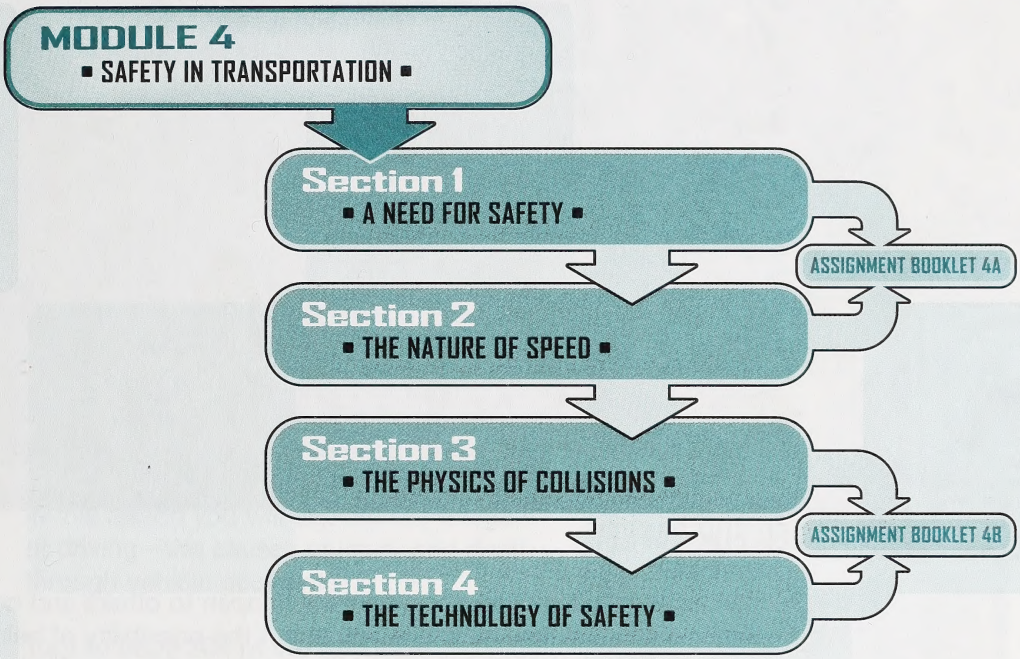


Module Overview



Professional drivers, like the operator of the rig in the photograph, are among the best and most courteous drivers on the highway. Not only must they receive special training to handle their units, after they qualify and are on the road, they must be on continual lookout for their own safety and the safety of others. Transporting goods without mishap over long distances, at night, during the day, and in good and bad weather requires a positive attitude and a healthy respect for the rules of the road!

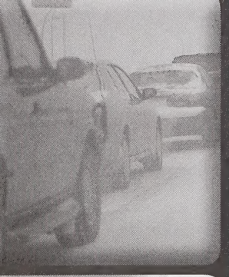
In this module you will explore safety in transportation. You will investigate the risks in operating motor vehicles and what governments and the transportation industry are doing to help reduce these risks. You will discover that safety systems and regulations are based mostly on science. Some of these underlying scientific principles you will explore are related to speed, distance, time, force, and momentum.

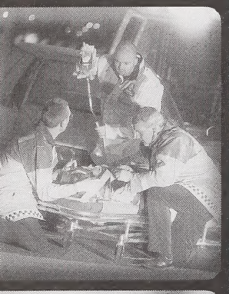


Assessment

This module, Safety in Transportation, has four section assignments. The mark distribution is as follows:

Assignment Booklet 4A	
Section 1 Assignment	25 marks
Section 2 Assignment	26 marks
Assignment Booklet 4B	
Section 3 Assignment	26 marks
Section 4 Assignment	23 marks
Total	**100 marks**





Section 1

A NEED FOR SAFETY

It is human nature to think that accidents will happen to others and not to you. When getting into a car, few people worry about the possibility of being involved in a motor vehicle collision. But the fact is that you are far more likely to be seriously injured or killed in a vehicle collision than in a plane crash. You've probably seen how nervous some people are when boarding a plane. They should, actually, be far more nervous getting into a car or a truck!

Safety experts will tell you that most vehicle collisions are preventable—driver error being the cause of most collisions. When you're driving, what can you do to help reduce the risk of collisions, injuries, and even death? What can you do when you're a passenger?

In this section you will explore some of the causes of motor vehicle collisions and how they can be reduced or eliminated.

Turn to pages 232 and 233 of the textbook and read the introduction to "Chapter 13: A Need for Safety." Think about the questions asked in "Science Log." You will learn more about these questions in this section. Also, read over the points in "What You Will Learn," "Why It Is Important," and "Skills You Will Use" on page 233. These provide a brief overview of what will be covered in this section.

Lesson 1

Analyzing the Danger

Reading headlines like those in this newspaper, it's no wonder that a lot of people have a fear of flying. But, yet, most people do not have a fear of driving. Why is that? Did you know that far more people are killed or injured every year on Canada's roads and highways than the total number killed or injured in the Halifax explosion? In 2002 alone, 2936 were killed and 227 768 were injured in motor vehicle collisions!

LOCAL PRESS

Fatal Car Crash Claims Mother of Four

317 Killed in Plane Crash

Government Issues New Regulations

More Care Required

In this lesson you will explore the dangers of driving—the causes of injury and death through vehicle accidents.

Turn to page 234 of the textbook and read the introductory paragraphs of "Analyzing the Danger."

1. Answer the question posed in "Reading Check."

2. What is the sad thing about the high number of traffic collisions in Canada?

Check your answers on page 89 of the Appendix.

In the next activity you will analyze the number of people injured or killed in traffic collisions in Alberta from 1995 to 1999.

Starting Point
Activity

Crash Statistics

Read the entire activity on page 233 of the textbook.

Complete the activity by following the instructions in "What to Do." You will create four different bar graphs—one for each category.

Note: You may wish to use a spreadsheet program to create the graphs for this activity.

3. Create a bar graph for each category: one for total collisions, one for number killed, one for number injured, and one for number of licensed Alberta drivers.

4. Answer questions 1, 2, and 3 of "What Did You Discover?" **Note:** You do not have to work with a partner or small group to answer question 3.

CHECK Check your answers on pages 89 and 90 of the Appendix.

Next, you will explore how deaths through motor vehicle collisions compare to other causes of death based on Canadian statistics from 1993–1997.

Find Out
Activity

What Are the Most Common Causes of Death?

Read the entire activity on pages 234 and 235 of the textbook.

Complete the activity by following the instructions in "What to Do."

5. Answer questions 1 to 6 of "What Did You Find Out?"

CHECK Check your answers on pages 90 to 92 of the Appendix.

In the next investigation you will analyze statistics showing the number of deaths involving various modes of transportation.

Investigation

13-A: How Safe Are You?

Read through this investigation as described on page 236 of the textbook.

Use the following tables of statistics to complete this investigation.

TABLE A: ANNUAL DEATHS BY TYPE OF ROAD USER

Road Users	Number of Deaths	
	1994–1998 (average)	1999
drivers	1557	1539
passengers	825	734
pedestrians	423	414
cyclists	71	69
motorcyclists	149	159
other	116	54

TABLE B: TYPES OF VEHICLES INVOLVED IN FATAL COLLISIONS

Vehicle Type	5-year average
automobiles	2552
light trucks/vans	1081
heavy trucks	534
motorcycles/mopeds	163
bicycles	77
other	235

TABLE C: PERCENTAGE OF DEATHS BY MODE OF TRANSPORT

Mode of Transport	Percentage of Total Transportation Fatalities
road	92.6
rail	2.0
air	4.4
marine*	1.0

*This does not include fatalities involving pleasure crafts.

6. Draw three bar graphs as described in "What to Do" on page 236 of the textbook.

7. Answer questions 1 to 4 of "Analyze" on page 236 of the textbook.

Check your answers on pages 93 and 94 of the Appendix.

In the previous activity you analyzed traffic fatalities. However, you are far more likely to be injured than killed in a traffic accident.

Turn to page 235 of the textbook and read "Injuries."

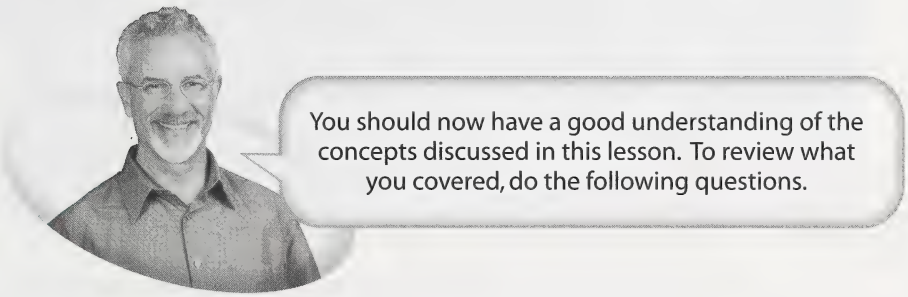
8. Answer the question posed in "Reading Check" on page 235.

9. Read "Did You Know?" on page 235. Why do you think more vehicle collisions happen on Friday than any other day of the week?

CHECK Check your answers on page 94 of the Appendix.

In this lesson you analyzed the risks in vehicular travel. Transport Canada addresses issues of road safety and provides current statistics. If you have access to the Internet, go to the following website to see the information Transport Canada has to offer:

http://www.tc.gc.ca/roadsafety/menu.htm


You should now have a good understanding of the concepts discussed in this lesson. To review what you covered, do the following questions.

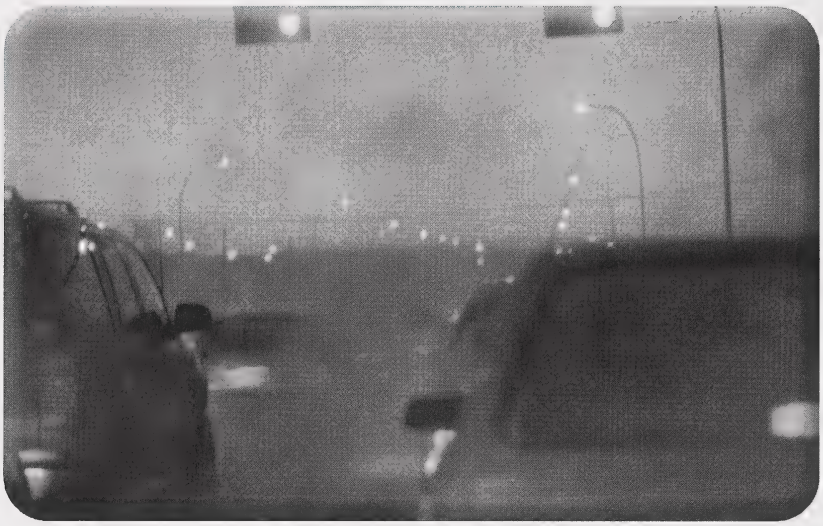
10. Answer questions 2 and 3 of "Check Your Understanding" on page 236 of the textbook.

CHECK Check your answers on page 94 of the Appendix.

Go to ... Go to pages 1 and 2 of Assignment Booklet 4A and answer questions 1 to 6.

Lesson 2

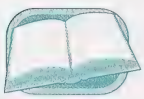
Reaction Time



In winter, drivers have to be particularly attentive to changing road conditions, reduced visibility, and other vehicles sharing the road. How quickly can you react to avoid a collision if the vehicle in front of you suddenly spun out of control? Whether you are driving in winter or summer conditions, your **reaction time** and decision-making ability is essential for your safety!

reaction time: the time it takes to recognize a problem and act on it

In this lesson you will explore your reaction time and factors that can affect it.



Turn to page 237 of the textbook. Read the introductory paragraphs of "Reaction Time."

1. Answer the questions posed in the first "Reading Check" on page 237 of the textbook.

Check your answer on page 95 of the Appendix.

Your reaction time is one of the factors that limits how fast you can safely drive. To test your reaction time and how it affects stopping distances at various speeds, insert the *Science 24 Multimedia* CD into your computer. Launch the "Reaction Time Java Applet," and follow the instructions. This applet will add to your understanding of reaction time and safe driving speeds.

2. What is the relationship between reaction time and stopping distance?

Check your answer on page 95 of the Appendix.

Your reaction time is slowed when you are distracted. Conversations, cell phones, smoking, eating, tuning in a radio station, and selecting a CD are some examples of distractions that can increase your reaction time and lead to accidents.

Turn to page 237 of the textbook and read the discussion in "Reaction Time and Distractions."

3. How might distractions slow reaction time?

Check your answer on page 95 of the Appendix.

The use of cell phones by drivers is very controversial. A number of jurisdictions have made the use of cell phones by drivers, while driving, illegal. Research regarding the degree to which drivers can be distracted by cell phones and other devices is available at Transport Canada's website:

http://www.tc.gc.ca/roadsafety/menu.htm

In the next investigation you will examine how distractions slow reaction times.

Investigation

13-B: Think Fast!

Read through the entire investigation on pages 238 and 239 of the textbook.

4. Answer questions 1 and 2 of "Prediction" on page 238 of the textbook.

Check your answers on page 95 of the Appendix.

Complete the activity by following the procedure carefully. If you are working at home, you can make your own metre-stick using a strip of wood that is about 100 cm long. Use a short ruler to mark off the 1-cm increments on the stick. A partner, such as a friend, brother/sister, or parent, is required for this investigation.

Use tables similar to the following to record your results for each part of the investigation. Round your averages to the nearest centimetre.

PART 1: REACTION TIME

Person	Trial				Average
	1	2	3	4	
1					
2					

PART 2: REACTION TIME WITH DISTRACTIONS

Step	Person	Trial				Average
		1	2	3	4	
8	1					
	2					
9	1					
	2					
10	1					
	2					

PART 3: REACTION TIME WHILE DIALING

Person	Trial				Average
	1	2	3	4	
1					
2					

PART 4: REACTION TIME WITH DIZZINESS

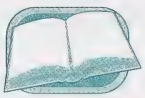
Person	Trial				Average
	1	2	3	4	
1					
2					

5. Answer the following on page 239 of the textbook.

   a. questions 1 to 4 of "Analyze"

   b. question 5 of "Conclude and Apply"

Check your answers on pages 95 to 97 of the Appendix.



Another factor that affects reaction time is fatigue. Read "Fatigue and Reaction Time" on page 240 of the textbook.

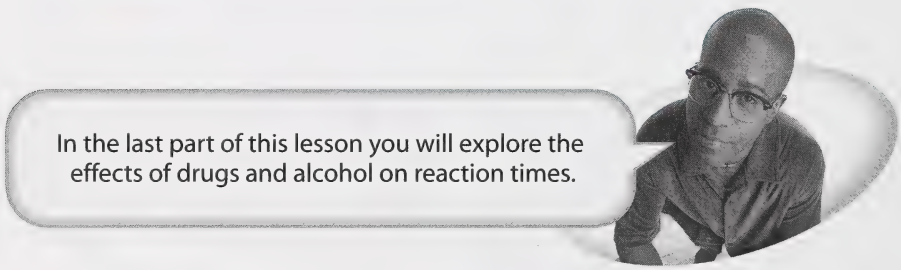
6. What percent of drivers have admitted to falling asleep while driving?

7. An exhausted or sleepy driver is often compared to a driver impaired by alcohol. How do they compare?

8. How well does drinking coffee work to speed up reaction time?

9. What is the only cure for a sleepy driver?

Check your answers on page 98 of the Appendix.



Turn to pages 240 and 241 of the textbook. Read "Reaction Time and Drugs," "Blood Alcohol Concentration," and "Blood Alcohol and the Law."

10. Why is alcohol called a depressant?

11. What happens to alcohol when it is consumed?

12. What in addition to alcohol can impair judgment?

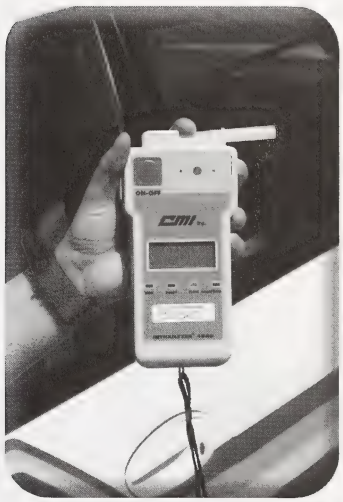
13. Define *blood alcohol concentration* (*BAC*).

14. If the BAC of a person is 0.12, how much alcohol is in each millilitre of the person's blood?

15. How is one drink defined?

16. How many "drinks" are contained in 450 mL of wine?

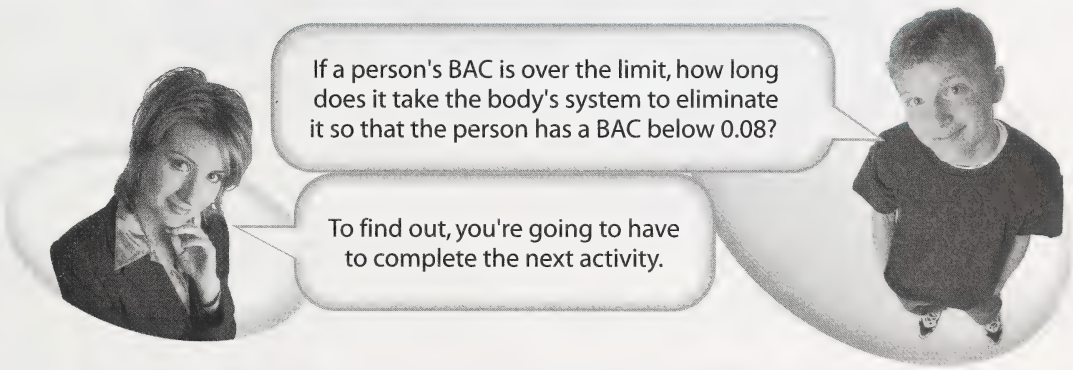
17. What is generally considered to be the legal limit of BAC in Canada?



Breathalyzer

18. Do you have to exceed 0.08 to be charged with impaired driving?

Check your answers on page 98 of the Appendix.


If a person's BAC is over the limit, how long does it take the body's system to eliminate it so that the person has a BAC below 0.08?
To find out, you're going to have to complete the next activity.

Turn to page 242 of the textbook and work through the sample problem in "Math Connect: How Soon Can a Drinker Drive?" Use the same procedure shown to answer these questions.

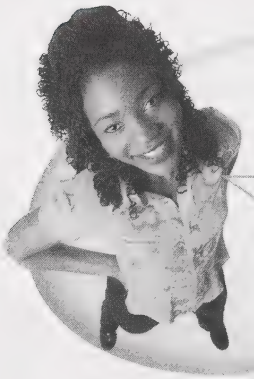
19. Do questions 1 and 2 of "Solve These" on page 242 of the textbook.

Check your answers on page 99 of the Appendix.

You should now have a good understanding of reaction times and factors that affect them. One of the major factors that contributes to impaired judgment and slows reaction time is alcohol. There are a number of organizations, such as Mothers Against Drunk Driving (MADD) and Students Against Drinking and Driving (SADD), that lobby for changes in the law and in society's attitudes towards drinking and driving.

If you have access to the Internet, you can find out more about these groups at these websites:

- **http://www.madd.ca**
- **http://www.saddalberta.com**



You have now covered all the concepts for this lesson. Do the following questions to review what you studied.

20. Answer questions 1 to 6 of "Check Your Understanding" on page 242 of the textbook.

CHECK Check your answers on page 100 of the Appendix.

Go to ... Go to page 3 of Assignment Booklet 4A and answer questions 7 to 12.

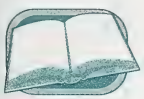
Lesson 3

Collision Injuries

Unfortunately, the sound of sirens from emergency vehicles racing to collisions in which people are injured is all too common. Nobody wants to be involved, or wants friends and loved ones to be involved, in a collision resulting in physical or emotional **trauma**. Cars can be repaired or replaced, but accidents can leave victims with permanent scars, physically and emotionally.

trauma: physical or emotional stress arising from a motor vehicle collision

In this lesson you will explore injuries arising from motor vehicle collisions.



Turn to page 243 of the textbook. Read the introductory paragraphs of "Collision Injuries."

1. What is trauma? Give three examples of trauma.

Check your answer on page 100 of the Appendix.

whiplash: the spraining of neck muscles and ligaments

Whiplash is a common injury drivers and passengers suffer when their vehicles are struck from behind.

Read "Whiplash" on page 243 of the textbook. **Note:** In the second paragraph, a statement reads that the head may fly forward and then backward during a collision. A headrest will help most when whiplash occurs if the vehicle is struck from behind and the head flies backward first and then forward.

Research whiplash injuries on the Internet or at your local library. Here is one website you can refer to:

http://www.vertigo-dizziness.com/english/whiplash_injury.html

2. Answer "Reading Check" at the bottom of page 243 of the textbook.

3. What are typical symptoms of whiplash?

CHECK Check your answers on page 101 of the Appendix.

Turn to page 244 of the textbook and read "Grief." Then complete the following activity.

Find Out Activity

What Happens After an Accident?

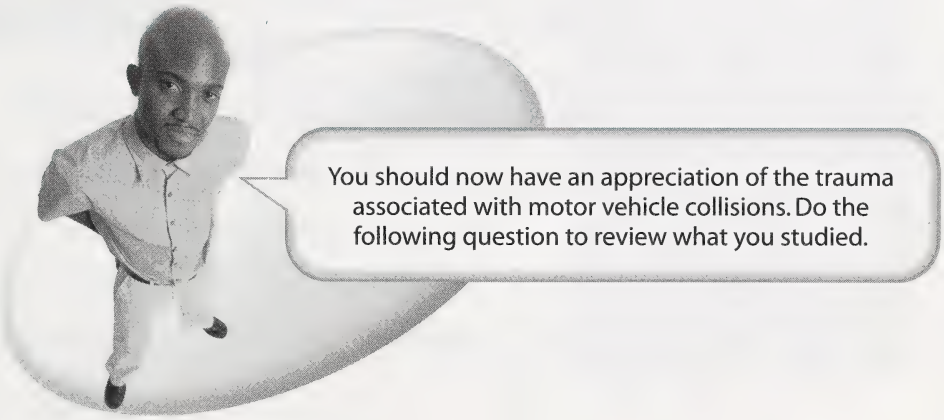
Read through the entire activity on page 244 of the textbook.

If you are not part of a classroom setting, you may wish to personally interview someone who works with accident victims. Your interview could be held over the telephone, via e-mail, or in person.

If you cannot contact any of these professionals directly, you may have to use the Internet to do your research. Follow the instructions in "Internet Connect."

4. Answer question 1 in "What Did You Find Out?"

Check your answer on page 101 of the Appendix.



You should now have an appreciation of the trauma associated with motor vehicle collisions. Do the following question to review what you studied.

5. Answer question 2 of "Check Your Understanding" on page 244 of the textbook.

Check your answer on page 101 of the Appendix.

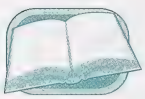
Go to page 4 of Assignment Booklet 4A and answer questions 13 and 14.

Lesson 4

Protection and Prevention

Recent improvements in motor vehicles and roads have made travel safer for drivers and their passengers. Seat belts, headrests, air bags, anti-lock braking systems, side-impact beams, energy-absorbing vehicle components, and dashboard designs are a few of the safety features engineered for modern automobiles. However, these improvements are only as good as the drivers' and passengers' healthy respect for the dangers on the road! Do you always wear a seat belt when riding in a car or truck?

In this lesson you will survey some of the safety features built into roads and vehicles to help protect you!



Turn to page 245 of the textbook and read "Safe Vehicles" and "Vehicle Maintenance."

1. Explain how each of these safety features is designed to protect you.

   a. anti-lock braking systems

   b. crumple zones

   c. side-impact beams

   d. seat belts

2. How many times more likely are people who don't wear seat belts to be injured than people who do wear seat belts?

3. Study Figure 13.10. What is the relationship between seat belt use and occupant fatalities?

4. Name three items you should regularly maintain on your vehicle to ensure your safety.

Check your answers on pages 101 and 102 of the Appendix.

In the next activity you will examine how seat belts work to restrain you in a collision.

Find Out
Activity

Driving with Restraint

Using the Internet or your local library, discover how seat belts work to protect you in the event of a collision. If you are using the Internet, enter words such as *seat belts* or *seat belt design* into any of the Internet's search engines.

Here is one website you may find useful:

http://auto.howstuffworks.com/seatbelt.htm

5. Summarize what you learned about seat belt design.

CHECK

Check your answer on page 102 of the Appendix.

Safety is also an important part of road design. Turn to page 247 of the textbook and read "Safe Roads."

6. Name four safety features built into roadways.

Check your answer on page 102 of the Appendix.

You have now covered all the concepts for this lesson. To review what you studied, answer the following questions.

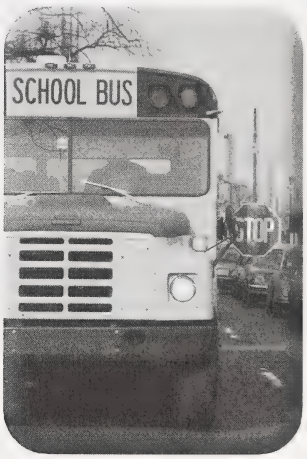
7. Answer questions 1 and 4 of "Check Your Understanding" on page 247 of the textbook.

Check your answers on page 102 of the Appendix.

Go to pages 4 and 5 of Assignment Booklet 4A and answer questions 15 to 18.

Section 1 Review

In this section you investigated the need for transportation safety. You explored data from traffic accidents. You examined the physical and emotional trauma arising from these accidents. You analyzed the data on traffic injuries and deaths and compared the data to other causes of injury and death among teenagers and adults. You investigated reaction times and factors that affect reaction times and discussed the consequences of shorter or longer reaction times. You then examined ways vehicles and highways have been designed to increase safety and actions you can take to protect yourself and others.



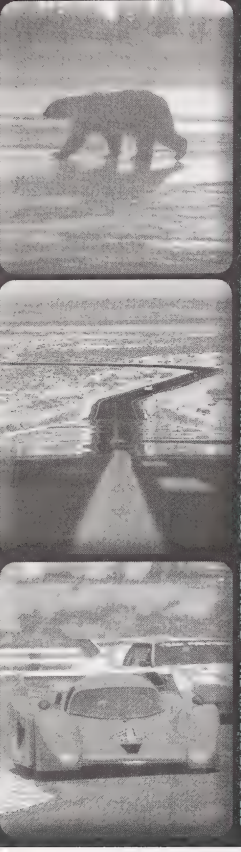
School buses are operated by professional drivers. Professional drivers always check to make sure their vehicles are mechanically sound before getting in and driving away. As well, professional drivers do not operate a vehicle when tired or when ill and on medication. Nothing must impair their judgment or reaction time. While on the road, professional drivers always give other drivers leeway. They are also better at anticipating danger, knowing that they, and others, are human and subject to error.

You have now completed the concepts for this section. To review what you covered, answer the following "Chapter 13 Review" questions on pages 248 and 249 of the textbook. If necessary, go back and read over the parts of this section as you answer the questions.

1. Answer question 2 of "Reviewing Key Terms."
2. Answer questions 3, 4, and 5 of "Understanding Key Ideas."
3. Answer question 6 of "Developing Skills."
4. Answer questions 8 and 10 of "Problem Solving/Applying."
5. Answer questions 11 and 13 of "Critical Thinking."

CHECK

Check your answers on pages 102 to 104 of the Appendix.



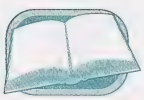
Section 2

THE NATURE OF SPEED

JEREMY DAVEY. REPRODUCED WITH KIND PERMISSION OF SSC PROG

A race car travels at high speeds. One particularly fast car, the ThrustSSC, set the World Land Speed Record of 1221 km/h, or Mach 1.02, on October 15, 1997. This record was established in the Black Rock Desert of Nevada, just two days after the same vehicle broke the speed of sound. October 13, 1997, was the first time the speed of sound was exceeded on land by a vehicle that was not travelling on rails. To establish the World Land Speed Record, the ThrustSSC had to cover a set distance twice, in opposite directions, within 60 minutes. The quest to set speed records on land, water, and in the air has sparked international competition for over a hundred years!

In this section you will explore speed, how it is defined and calculated, how it is represented by graphs, and how it is related to transportation safety.



Read the introduction to "Chapter 14: The Nature of Speed" on pages 250 and 251 of the textbook. After reading the introduction, read "Science Log." Think about the questions asked. You will learn more about these questions in this section. You should also read "What You Will Learn," "Why It Is Important," and "Skills You Will Use" on page 251. These provide a brief overview of what will be covered in this section.

Lesson 1

Defining Velocity

Have you ever seen an ambulance speeding down the road to get to an accident scene? Drivers are expected, by law, to pull over to the right and stop by the side of the road to allow the ambulance (and any other emergency vehicle for that matter) to pass unimpeded. Speed is critical in getting to victims. The faster the ambulance can safely travel, the shorter the response time will be!

How good are you at estimating the speed of the vehicle in which you are travelling? How accurately can you estimate the speed of vehicles while in a parked car or while walking down a sidewalk? In this lesson you will explore how speed, or **velocity**, is defined.

velocity: speed; rate of change of position

Note: Throughout this module you will use the terms *speed* and *velocity* interchangeably to remain consistent with the textbook.

In physics there is a difference between velocity and speed. Velocity indicates direction, whereas speed does not. The calculations for the magnitude of both are the same, so the terms are often used interchangeably.

Turn to page 252 of the textbook and read the information of "Defining Velocity."

1. Answer the questions posed in "Reading Check."

2. The speed limit on some rural roads is 80 km/h. How far would you travel in one hour at that speed?

CHECK Check your answers on page 104 of the Appendix.

What was the fastest you ever travelled? 100 km/h? 200 km/h? 1000 km/h? The next activity explores your conception of speed.

Starting Point
Activity

How Fast Is *Fast*?

Read through the entire activity on page 251 of the textbook. You may need to discuss the questions with someone else if you cannot provide answers from your own experience.

3. Answer questions 1 to 4 of "What to Do."

CHECK Check your answers on pages 104 and 105 of the Appendix.

In the next investigation you will determine the speed of a moving object.

Investigation

14-A: Discovering Velocity

Read the entire investigation on page 253 of the textbook.

If you have access to a stopwatch (or a wristwatch with a stop/start button), do **Part A**. If you do not have access to a stopwatch (or wristwatch), do **Part B**.

Part A

Follow the steps outlined in "Design Criteria" and "Plan and Construct."

4. Answer questions 1, 2, and 3 of "Evaluate."

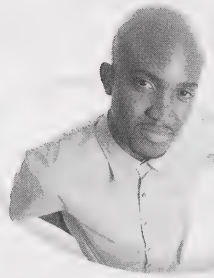
Check your answers on page 105 of the Appendix.

Part B

Two students used a remote-controlled car in their investigation. They marked distances of 0 m, 2 m, 4 m, and 6 m on the gym floor with masking tape. While one student controlled the car, the other student used a stopwatch to time the car. They recorded the time the car took to cover 2 m, 4 m, and 6 m. Here are their results.

Trial	Distance	Time
1	2 m	1.5 s
2	4 m	2.9 s
3	6 m	4.4 s

Use the given data to answer question 4 in Part A.



The investigation you just completed involved calculating velocity from time and distance. Did you use a formula to perform these calculations?

Turn to pages 254 and 255 of the textbook. Read the discussion in "Calculating Velocity." Then work through the two sample problems in "Math Connect: Using the Formula for Velocity."

5. Answer questions 1 to 4 of "Solve These" on page 255 of the textbook.

CHECK Check your answers on pages 106 and 107 of the Appendix.

In the preceding questions you calculated velocity either in m/s or km/h. How would you convert one set of units into the other?

Example

The speed limit on many Alberta highways is 100 km/h. What is this speed in m/s?

Solution

$$100\ \text{km/h} = \frac{100\ \text{km}}{1\ \text{h}}$$

Convert kilometres into metres.

$$= \frac{100\ \cancel{\text{km}}}{1\ \cancel{\text{h}}} \times \frac{1000\ \text{m}}{1\ \cancel{\text{km}}} \times \frac{1\ \cancel{\text{h}}}{60\ \cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\ \text{s}}$$

Convert hours into seconds.

$$= \frac{100\ 000\ \text{m}}{3600\ \text{s}}$$

$$= 27.78\ \text{m/s}$$

The velocity of a car travelling 100 km/h is approximately 27.78 m/s.

Example

Jesse used her stopwatch to time a car travelling a distance of 50 m. The car covered this distance in 2 s. How fast was the car travelling in m/s and in km/h?

Solution

Use the formula for velocity.

$d = 50\ \text{m}$, $t = 2\ \text{s}$, and $v = ?$

$$v = \frac{d}{t}$$

$$v = \frac{50\ \text{m}}{2\ \text{s}}$$

$$v = 25\ \text{m/s}$$

The car was travelling 25 m/s.

Convert 25 m/s to km/h.

Method 1

$$25\ \text{m/s} = \frac{25\ \text{m}}{1\ \text{s}}$$

$$= \frac{25\ \cancel{\text{m}}}{1\ \cancel{\text{s}}} \times \frac{1\ \text{km}}{1000\ \cancel{\text{m}}} \times \frac{3600\ \cancel{\text{s}}}{1\ \text{h}}$$

Convert metres into kilometres.

Convert seconds into hours.

$$= \frac{90\ 000\ \text{km}}{1000\ \text{h}}$$

$$= \frac{90\ \text{km}}{1\ \text{h}} \text{ or } 90\ \text{km/h}$$

Method 2

$$25 \text{ m/s} = \frac{25 \text{ m}}{1 \text{ s}}$$

$$= \frac{25 \text{ m}}{1 \cancel{\text{s}}} \times \frac{3600 \cancel{\text{s}}}{1 \text{ h}}$$

← Recall that there are 3600 s in 1 h. So, a car travelling 25 m/s would travel 3600 times further in 1 h.

$$= \frac{90\,000 \text{ m}}{1 \text{ h}}$$

$$= \frac{\frac{90\,000 \text{ m}}{1000 \text{ m/km}}}{1 \text{ h}}$$

← There are 1000 m in 1 km. So, divide 90 000 by 1000.

$$= \frac{90 \text{ km}}{1 \text{ h}} \text{ or } 90 \text{ km/h}$$

The car was travelling 90 km/h.

6. Now, it's your turn. Convert the following.

   a. 50 km/h into m/s

   b. 50 m/s into km/h

Check your answers on page 107 of the Appendix.

You have now completed the concepts for this lesson.
Do the following questions to review what you studied.

7. Answer questions 1 to 4 of "Check Your Understanding" on page 255 of the textbook.

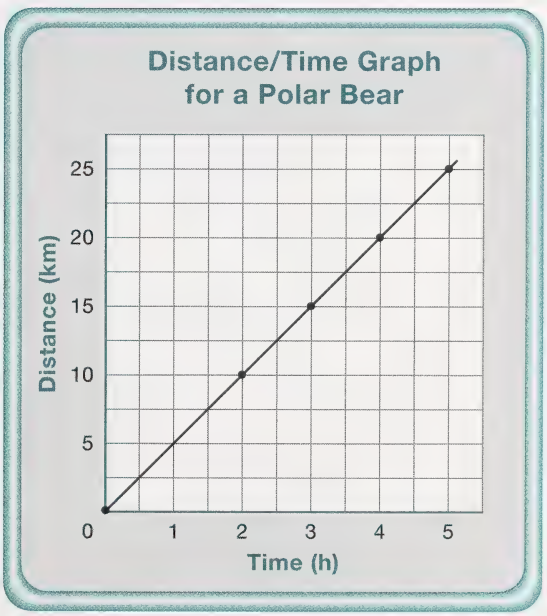
CHECK Check your answers on page 108 of the Appendix.

Go to ... Go to pages 5 and 6 of Assignment Booklet 4A and answer questions 1 to 5.

Lesson 2

Graphing Velocity

A polar bear is travelling 5 km/h through its territory. After 1 h, it covered 5 km; after 2 h, it covered 10 km; and so on. A biologist studying the polar bear graphed the distance it travelled every hour for five hours. She plotted time on the *x*-axis (horizontal axis) and distance on the *y*-axis (vertical axis). This graph (shown on the right) is an example of a distance/time graph.



In this lesson you will explore velocity and its relationship to the **variables** involved in distance/time graphs.

variable: a quantity that can change

Turn to page 256 of the textbook and read the introduction to "Graphing Velocity." Then continue on by reading "Distance/Time Graphs."

1. a. Define *manipulated variable*.

   b. What is the manipulated variable in a distance/time graph?

2. a. Define *responding variable*.

   b. What is the responding variable in a distance/time graph?

Check your answers on page 108 of the Appendix.

Example

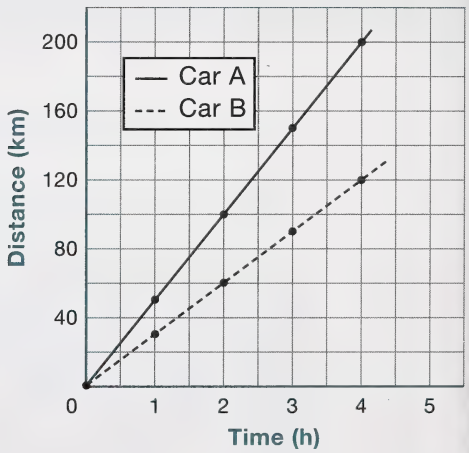
Use the graph on the right to answer questions (a) to (c).

(a) How far does Car A travel every hour? What is its velocity?

(b) How far does Car B travel every hour? What is its velocity.

(c) Which graph has the steeper slope? What does a steeper slope tell you?

Distance/Time Graph for Two Cars



Solution

(a) Car A travels 50 km every hour. Its velocity is 50 km/h.

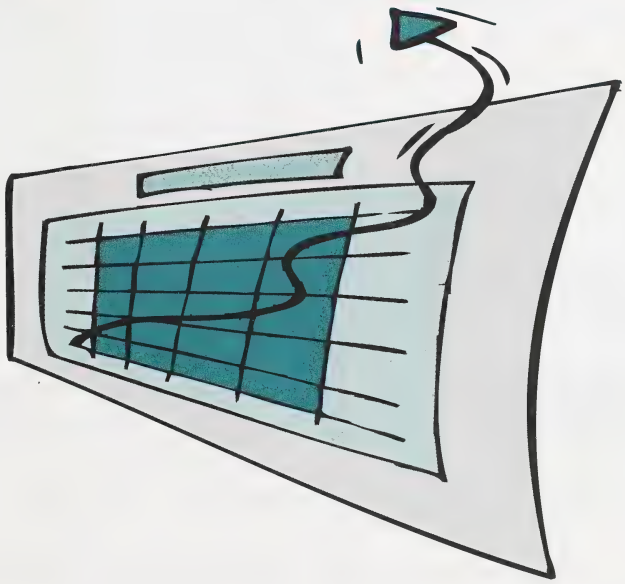
(b) Car B travels 30 km every hour. Its velocity is 30 km/h.

(c) Car A's graph has a steeper slope. A steeper slope means a faster speed or velocity.

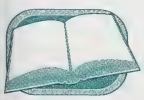
The reading on page 256 of the textbook stated that the slope of a distance/time graph gives information about the velocity of the object. After working through the example, do you see how velocity can be interpreted from the slope?

3. Answer the question posed in "Reading Check" on page 256 in the textbook.

Check your answer on page 108 of the Appendix.



In the preceding example, the graphs were straight lines because both cars were travelling at constant speeds. What would the graph look like if speed is not constant?



Turn to page 257 of the textbook and read "Constant Velocity, Changing Velocity."

4. What is the go-kart's velocity?

5. How can you tell from the graph that the go-kart's velocity is constant?

6. Complete the following table for the dune buggy. You will have to estimate the distances. The time for each period is 1 s.

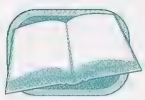
Time Period	Distance Travelled	Velocity
from $t = 0$ s to $t = 1$ s	$7\ m\ (7\ m - 0\ m)$	$7\ m/s$
from $t = 1$ s to $t = 2$ s	$10\ m\ (17\ m - 7\ m)$	
from $t = 2$ s to $t = 3$ s		
from $t = 3$ s to $t = 4$ s		
from $t = 4$ s to $t = 5$ s		

7. When was the dune buggy travelling the fastest? the slowest? How can you tell just by looking at the graph?

Check your answers on page 109 of the Appendix.

Next, you will apply what you have learned about constant velocity in the following activities.

What Are You Plotting?



Turn to page 257 of the textbook and read through the entire activity.

8. Answer questions 1, 2, and 3 in "What to Do."

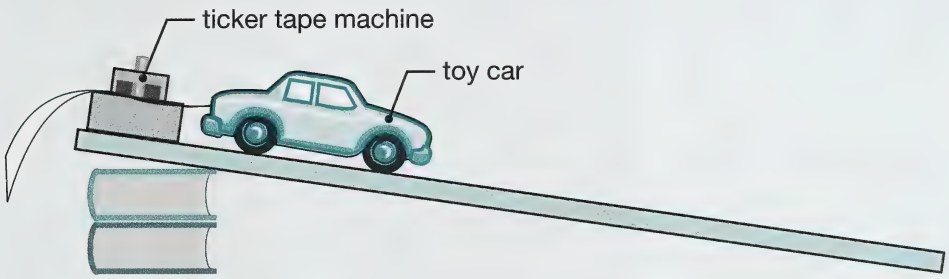
9. Answer questions 1, 2, and 3 in "What Did You Find Out?"

Check your answers on pages 109 and 110 of the Appendix.

Investigation

14-B: Graphing Motion

Turn to pages 258 and 259 of the textbook and read the entire investigation.



If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

Part A

Follow the steps of the procedure carefully. **Note:** The ticker tape shown on page 259 was started while the cart was accelerating down the ramp.

10. Complete steps 5 to 7 of the procedure. In step 5 you need to measure the distances from P0 to each dot in the series following P0.

11. Answer the following on page 259 of the textbook.

    a. questions 1 and 2 of "Analyze"

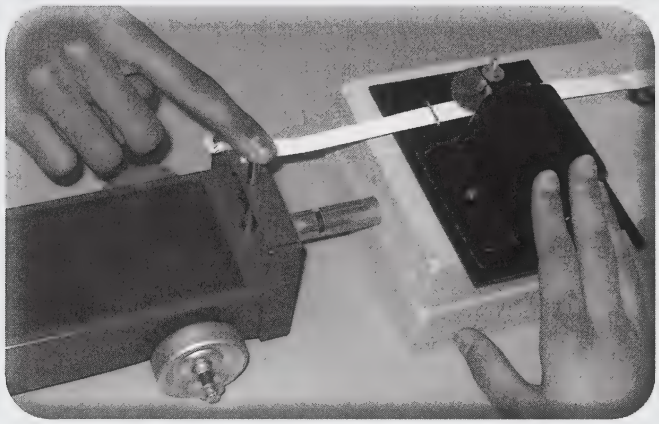
    b. question 3 of "Conclude and Apply"

    c. question 4 of "Extend Your Skills"

CHECK Check your answers on pages 110 and 111 of the Appendix.

Part B

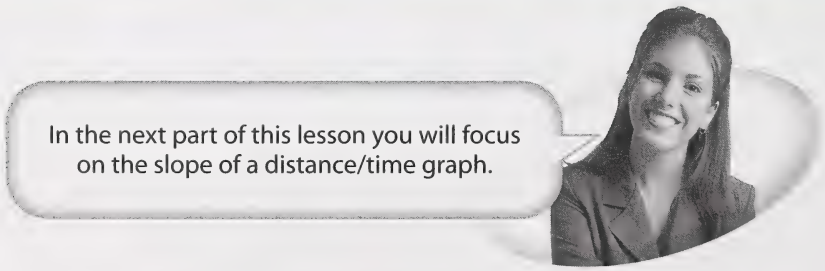
Two students performed this investigation in a supervised laboratory. They set the ticker tape machine at 30 ms and released the dynamics cart down the ramp. Obtain the ticker tape at the back of the Appendix showing the students' results.



12. Do steps 5 to 7 of the procedure. In step 5 you need to measure the distance from P0 to each dot in the series following P0. Since the ticker tape machine is set for 30 ms, the time from dot to dot is 30 ms or 0.03 s (30 ÷ 1000).

13. Answer question 11 in Part A.

Check your answers on pages 111 and 112 of the Appendix.



Turn to pages 260 and 261 of the textbook. Read the discussion in "Calculating Velocity from a Distance/Time Graph." Then study the procedure in "Math Connect: Slope Formula," and work through the sample problem. Remember, time is on the *x*-axis and distance is on the *y*-axis.

run: the horizontal distance between two points on a graph

rise: the vertical distance between two points on a graph

14. For the line between two points on a distance/time graph, what does the **run** represent?

15. For the line between two points on a distance/time graph, what does the **rise** represent?

16. How is slope defined?

17. For the line between two points on a distance/time graph, what does the slope represent?

18. Answer question 1 of "Solve These" on page 261 of the textbook.

CHECK Check your answers on page 112 of the Appendix.

Insert the *Science.Connect 2 Student Multimedia* CD into your computer. Launch the "Velocity" applet, and work through each part for additional information on graphing velocity and determining velocity from the slope of a distance/time graph.

19. Answer questions 1 to 4 of "Check Your Understanding" on page 261 of the textbook.

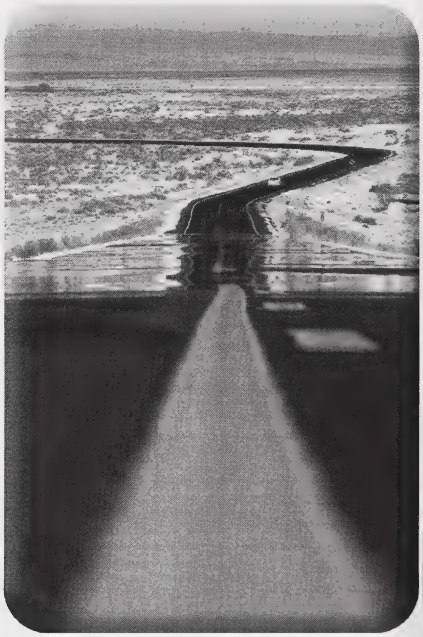
CHECK Check your answers on page 113 of the Appendix.

Go to ... Go to pages 6 to 8 of Assignment Booklet 4A and answer questions 6 to 15.

Lesson 3

Calculating Distance

Tamara and Ethan are taking a long trip by car. Just like any long trip, the last few kilometres seem to go on forever! Ethan, who is in the passenger seat, glances at the map. He tells Tamara that if they keep going 100 km/h, they should arrive in three-quarters of an hour. How far do Tamara and Ethan have left to drive?



To answer this question, you need to be able to calculate distance given the velocity and time. In the previous lesson, you were introduced to the velocity formula, $v = \frac{d}{t}$. To calculate distance, you must rearrange this formula and solve it for d.

$$v = \frac{d}{t}$$

$$\frac{d}{t} = v$$

$$\frac{d}{t} \times t = v \times t$$

$$d = vt \quad \leftarrow \text{distance} = \text{velocity} \times \text{time}$$

In this lesson you will apply this formula to solve a variety of distance problems.

Turn to page 262 of the textbook and read the introductory paragraphs of "Calculating Distance." Then work through the sample problems in "Math Connect: Using a Distance/Time Graph to Calculate Distance Travelled" on pages 262 and 263.

1. Answer the question posed in "Try This!" on page 262 of the textbook.

2. Answer questions 1 and 2 of "Solve These," on page 263 of the textbook.

CHECK Check your answers on pages 113 and 114 of the Appendix.

You should have a good understanding of calculating distance from velocity and time! Answer the following questions to review what you covered in this lesson.

3. Answer the question in the introduction to this lesson.

4. Answer questions 1, 2, 3, and 4.a. of "Check Your Understanding" on page 263 of the textbook.

Note: The log book on page 263 of the textbook uses a 24-hour clock for time. Time on a 24-hour clock starts with 01:00 at 1:00 A.M. and ends with 24:00 at midnight. Therefore, 13:00 is 1:00 P.M., 13:30 is 1:30 P.M., and 16:00 is 4:00 P.M.

CHECK Check your answers on page 115 of the Appendix.

Go to ... Go to page 9 of Assignment Booklet 4A and answer questions 16 to 18.

Lesson 4

Distance Travelled During Reaction Time

A cause of many accidents on city streets and provincial highways is the bad practice of following vehicles too closely. When a vehicle ahead slows or stops suddenly, a driver following too close cannot react quickly enough and ends up rear-ending the vehicle in front of him or her. Safety experts recommend that drivers should leave at least a two-second gap between themselves and the car in front.

In many jurisdictions in Europe, V-shaped pavement markings, called chevrons, are painted at regular intervals on highways. Drivers are warned to keep two chevrons between themselves and the vehicles they are following. This provides the approximate two-second cushion. Pennsylvania adopted this strategy using painted dots on highways. Signs let drivers know to maintain a gap of two dots when following another vehicle. When this program was introduced on Route 11 in October 2000, the number of rear-end collisions reduced by approximately 60% for the first six months.

In this lesson you will explore reaction times and stopping distances.

As you discovered in Section 1, reaction times vary. In the next example you will estimate the distance your car would travel at 110 km/h during a reaction time of 0.5 s.

Example

A driver is travelling 110 km/h on a highway. A deer darts onto the road ahead. The driver's reaction time is 0.5 s. How many metres will his car travel before the driver steps on the brakes? (Round your answer to the nearest metre.)

Solution

The vehicle's speed, v, is given in km/h. You need to convert km/h to m/s. To do this, you must convert kilometres into metres and hours into seconds.

Convert kilometres into metres.

$$110 \text{ km/h} = \frac{110 \text{ km}}{1 \text{ h}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}}$$

Convert hours into seconds.

$$= \frac{110\,000 \text{ m}}{3600 \text{ s}}$$

$$= 30.56 \text{ m/s}$$

In Lesson 3 you used the formula $d = vt$ to determine the distance, d, from velocity, v, and time, t.

$v = 30.56$ m/s, $t = 0.5$ s, $d = ?$

$d = vt$

$d = 30.56 \text{ m/s} \times 0.5 \text{ s}$

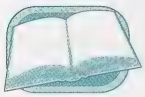
$d = 15.28$ m

The distance travelled during the reaction time is about 15 m.

Now it's your turn!

1. If your reaction time is 0.75 s, calculate the distance your car would travel before hitting the brakes at 100 km/h. (Round your answer to the nearest metre.)

Check your answer on page 116 of the Appendix.



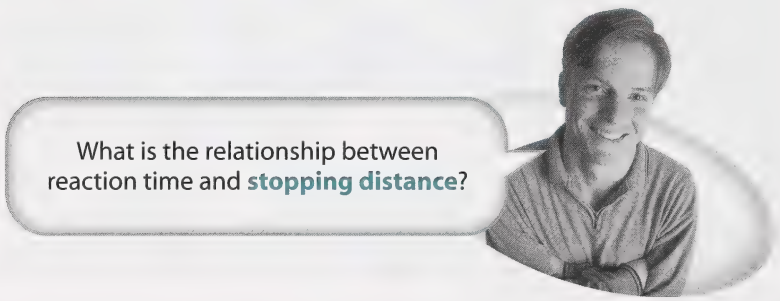
Turn to page 264 of the textbook. Read the introduction to "Distance Travelled During Reaction Time."

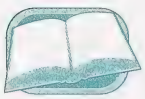
2. Answer the question posed in "Reading Check" at the top of page 264.

3. Answer the question posed in "Try This!" on page 264 of the textbook.

Check your answers on pages 116 and 117 of the Appendix.

stopping distance: the distance travelled during a driver's reaction time plus the braking distance





Turn to pages 264 and 265 of the textbook. Read the discussions in "Reaction Time and Stopping Distance" and "Following Distance."

4. Write a word formula for stopping distance.

5. Answer questions 1 and 2 that follow Table 14.2 on page 265 of the textbook.

6. Answer the question posed in "Reading Check" on page 265 of the textbook.

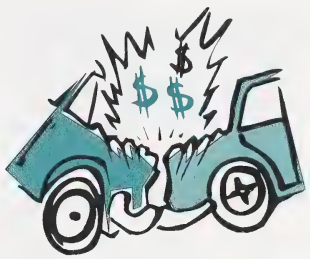
Check your answers on page 117 of the Appendix.

You should now have a good understanding of the relationship between velocity and distance/time graphs. To extend the concepts of this lesson, insert the *Science.Connect 2 Student Multimedia* CD into your computer. Launch the applet "Stop That Car!" Answer the following questions as you work through the applet.

7. What percentage of vehicle accidents are due to excessive speed?

8. About how many times does braking distance increase when speed is doubled?

9. Name four factors that increase a vehicle's braking distance.



10. What is the range of reaction times for drivers who are not impaired?

CHECK Check your answers on pages 117 and 118 of the Appendix.

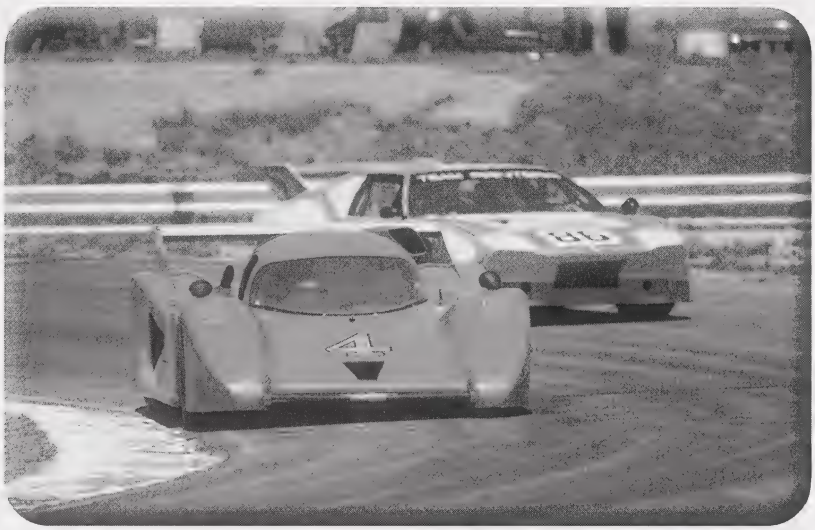
11. Answer questions 1 to 4 of "Check Your Understanding" on page 265 of the textbook. To help you answer question 1, plot a graph of velocity (manipulated variable) versus stopping distance (responding variable) using the data in Table 14.2.

CHECK Check your answers on page 118 of the Appendix.

Go to ... Go to page 10 of Assignment Booklet 4A and answer questions 19 to 22.

Section 2 Review

In this section you studied velocity. You examined its definition and explored how velocity is related to the slope of distance/time graphs. As well, you applied a formula to solve a variety of everyday problems involving velocity, time, and distance. In particular, you investigated how velocity affects the distance travelled during reaction times and how it is related to vehicle stopping distances.



Speed has always fascinated people. People have sought to establish speed records on land, water, in the air, and even in space. In the photograph, a couple of race cars speed around a bend in the race track. You were introduced earlier to the ThrustSSC, which was the first land vehicle to break the sound barrier. Speeding on a race track or on a desert lake bed is one thing, but there is no place for speeding excessively on city streets or on provincial highways!

You have just completed the concepts for this section. To review what you studied, do the following questions. If necessary, go back and read over the parts of this section as you answer the questions.

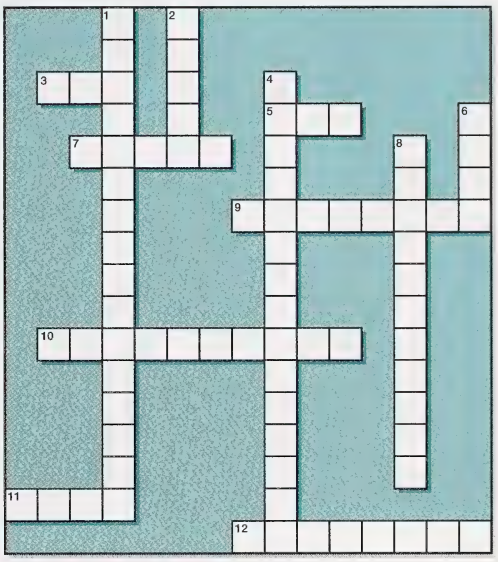
1. Complete the following puzzle.

Across

3. the number of seconds you should leave between your vehicle and the one ahead
5. horizontal distance between two points on a distance/time graph
7. another term for velocity
9. the product of velocity and time
10. the term for a variable affected by changes to the manipulated variable
11. measured in hours or seconds
12. distance divided by time

Down

1. distance travelled during reaction time plus braking distance (2 words)
2. rise over run
4. how far a vehicle travels after the brakes are applied (2 words)
6. vertical distance between two points on a distance/time graph
8. the term for a variable you change



2. Answer the following "Chapter 14 Review" questions on pages 266 and 267 of the textbook.

   a. questions 2 and 3 of "Reviewing Key Terms"

   b. questions 4 and 5 of "Understanding Key Ideas"

   c. question 6 of "Developing Skills"

   d. questions 9, 10, and 11 of "Problem Solving/Applying"

   e. question 12 of "Critical Thinking"

Check your answers on pages 119 to 121 of the Appendix.

Section 3

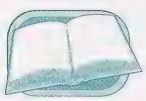
THE PHYSICS OF COLLISIONS

EUGENE ERICK/MEDICINE HAT TIGERS HOCKEY CL

Hard hitting is part of the game of hockey. Spectators enjoy seeing a player from their team deliver a clean body check to a player from the opposing team. In hockey, the players' equipment and the rink's boards and glass are designed to protect the players as much as possible from injury. Nevertheless, in spite of every precaution, players still get injured!

Now, imagine two vehicles, each with a mass over ten times that of a hockey player and each travelling 10 times faster. If they were to collide, injury to drivers and occupants, in spite of all the safety features, would almost be a certainty!

In this section, you will investigate the physics of collisions. You will explore momentum and mass, the forces underlying changes in momentum, and the conservation of momentum during collisions.



Turn to page 268 and 269 of the textbook and read the introduction to "Chapter 15: The Physics of Collisions." After reading the introduction, read "Science Log." Think about the questions asked. You will explore these questions in this section. You should also read over the points in "What You Will Learn," "Why It Is Important," and "Skills You Will Use" on page 269. These provide a brief overview of what will be covered in this section.

Lesson 1

Momentum and Mass

When stopped at a level crossing waiting for a freight train to go by, do you count the rail cars to pass the time? On the prairies, it not unusual to see trains a kilometre or more in length with well over 100 cars. A freight train pulling 150 cars can weigh as much as 5000 automobiles. This train travelling 80 km/h would need almost 2.5 km to stop. This is one reason why when a train collides with a car, it is much like a car running over a tin can.

Did you know?

In spite of stop signs, barriers, and flashing lights, in North America a vehicle or pedestrian is hit, on average, every two hours by a train. Most of these incidents even happen at level crossings. Did you know that if your car collides with a train, you are 30 times more likely to be killed than in a collision with another car?

In this lesson, you will explore how the mass of an object in motion affects the **force** needed to change its speed, slow it down, or stop. How large a force do you think is required to stop a freight train travelling 100 km/h?

force: a push or a pull

Turn to page 270 of the textbook and read the introductory paragraphs of "Momentum and Mass."

1. What is momentum?

2. What is force?

3. Answer the question posed in "Reading Check" on page 270 of the textbook.

4. What is the relationship between a moving object's momentum and the force and time required to stop the object?

Check your answers on page 122 of the Appendix.

In the next activity, you will be introduced to factors that determine the magnitude of the momentum of a moving object.

Starting Point
Activity

Getting More Oomph

Read the entire activity on page 269 of the textbook.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

Part A

Follow the steps in "What to Do" with the following modification:

> For step 2, determine how long it will take the cart to travel from the bottom of the ramp to the box.

5. Record your observations in a table similar to the following.

Cart	Time from Bottom of Ramp to Box	Distance from Bottom of Ramp to Box	Velocity of Cart	Distance Box Travelled
empty				
with 100-g mass				
with 200-g mass				
empty on ramp raised to double original height				
with 100 g on ramp raised to double original height				
with 200 g on ramp raised to double original height				

6. What conclusion can you draw about the momentum of the cart when mass is increased? Compare the distance the box travelled when the mass of the cart changed.

7. What conclusion can you draw about the momentum of the cart when velocity is increased? Compare the distance the box travelled when the height of the ramp changed.

Check your answers on page 122 of the Appendix.

Part B

A student completed the activity and obtained the following data.

8. Complete the following table by calculating the velocity of the cart for each situation.

Cart	Time from Bottom of Ramp to Box	Distance from Bottom of Ramp to Box	Velocity of Cart	Distance Box Travelled
empty	0.50 s	1 m		50 cm
with 100-g mass	0.50 s	1 m		60 cm
with 200-g mass	0.50 s	1 m		70 cm
empty on ramp raised to double original height	0.25 s	1 m		100 m
with 100 g on ramp raised to double original height	0.25 s	1 m		120 cm
with 200 g on ramp raised to double original height	0.25 s	1 m		140 cm

9. Answer questions 6 and 7 in Part A.

Check your answers on page 122 of the Appendix.

In the Starting Point Activity you discovered that momentum increases when mass or velocity increases. In the next part of this lesson, you will apply a formula to calculate momentum.

Read "Calculating Momentum" on page 271 of the textbook. Then work through the sample problem in "Math Connect: Calculating Momentum."

10. Answer the question posed in "Reading Check" on page 271 of the textbook.

11. On page 271 of the textbook, complete the table in "Solve These." **Note:** For more accurate calculations of momentum, convert the velocity from km/h into m/s (to one decimal place).

CHECK Check your answers on page 123 of the Appendix.

To slow down or stop a moving vehicle, you must decrease its momentum. Turn to page 272 of the textbook and read "Slowing Momentum" to explore the forces involved.

The textbook defines friction one way on page 272 and another way in the glossary. You can think of friction in different ways. Friction that is the result of objects rubbing together produces heat. Brakes on a vehicle are an example of this type of friction. The friction that keeps you standing on a surface or that provides the traction for tires on a motor vehicle is often called static friction.

12. What is the best way to reduce the momentum of a vehicle?

13. What is friction? Check the glossary definition in the textbook.

14. How does braking use friction to reduce the momentum of a vehicle?

15. Answer the question posed in "Reading Check" on page 272 of the textbook.

CHECK Check your answers on page 123 of the Appendix.

If you are interested in getting more information on how brakes work, enter the words *heat dissipation* and *brakes* into any of the Internet's search engines. The following site provides a detailed explanation of how brakes work:

http://www.babcox.com/editorial/bf/bf10312.htm

In the next activity you will study how the mass of a dynamics cart affects the distance it travels before friction slows it to a stop.

Find Out Activity

Friction, Mass, Force, and Stopping

Read the entire activity on page 273 of the textbook.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

Part A

Follow the steps in "What to Do" carefully.

16. Complete a table similar to the following.

Cart	Total Mass	Distance Cart Travelled
empty		
with 100-g mass		
with 500-g mass		

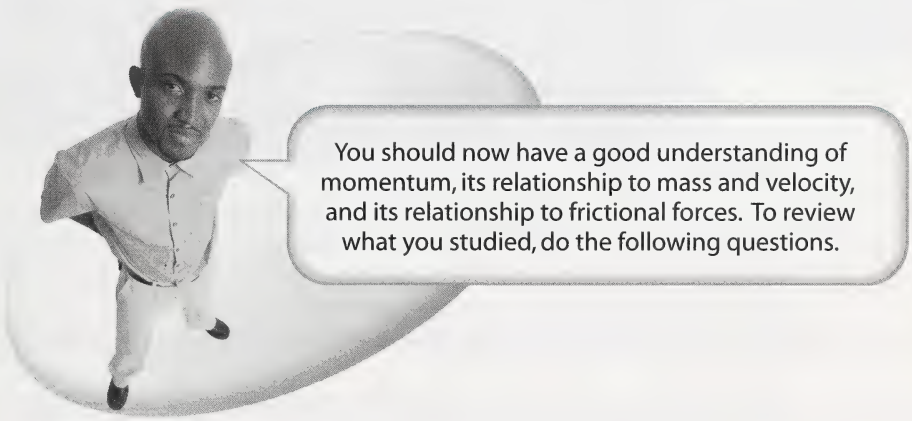
17. Answer questions 1, 2, and 3 of "What Did You Discover?"

Check your answers on page 124 of the Appendix.

Part B

A student completed the activity. This is the data she obtained. Use this data to answer question 17 in Part A.

Cart	Total Mass	Distance Cart Travelled
empty	500 g	4.0 m
with 100-g mass	600 g	4.8 m
with 500-g mass	1000 g	8.0 m


You should now have a good understanding of momentum, its relationship to mass and velocity, and its relationship to frictional forces. To review what you studied, do the following questions.

18. Answer questions 1, 2, and 3 of "Check Your Understanding," on page 273 of the textbook.

CHECK Check your answers on page 125 of the Appendix.

Go to ... Go to pages 1 and 2 of Assignment Booklet 4B and answer questions 1 to 6.

Lesson 2

Changing Momentum Is Related to Force

A driver transporting a heavy load must be careful when slowing down. Of course the driver has the choice of braking slowly or abruptly; but braking abruptly risks losing the load, having it shift dangerously, or having the trailers jack-knife. It is much safer to apply a low braking force over a long distance than to risk an accident by applying a large braking force over a short distance!

In this lesson you will investigate the forces needed to change the momentum of moving objects.

Turn to page 274 of the textbook and read the introduction to "Changing Momentum Is Related to Force." Pay particular attention to the formula for impulse. Once you have completed the reading, work through the sample problem in "Math Connect: Calculating Impulse" on page 275 of the textbook.

1. What is meant by the term *impulse*?

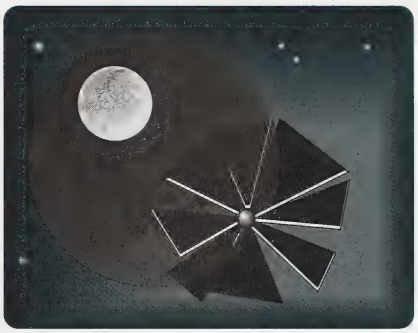
2. What is the relationship between impulse and a change in momentum?

3. What is the formula for impulse?

4. What is the unit for impulse? How is the unit for impulse related to the unit for momentum?

5. Answer questions 1 to 4 of "Solve These" on page 275 of the textbook.

Check your answers on pages 125 and 126 of the Appendix.



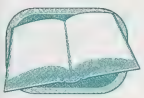
In the first part of this lesson, you discovered that you can increase or decrease momentum by applying a large force over a short period of time or by applying a small force over a long period of time.

Applying a small force over a long period of time is the principle behind the propulsion of spacecraft deploying a solar sail. A light breath of solar wind on the sail, built from extremely light-weight materials, over time should propel these crafts to the enormous speeds required for interstellar travel. The solar sail you see in the diagram was designed in and will be launched from Russia in 2004 as a prototype for these spacecrafts.

You can find out more about the solar sail in the diagram at the following website:

http://www.planetary.org/solarsail/missions/bold_new_voyage.html

You can also enter the words *solar sail* into any of the Internet's search engines to find a number of sites with information on solar sails.



Turn to page 275 of the textbook and read "Impulse and Force."

6. Answer the question posed in "Reading Check."

7. List two ways you can create a larger impulse.

Check your answers on page 126 of the Appendix.

In the next activity you will explore how changing momentum of a vehicle affects its occupants.

Find Out
Activity

Objects at Rest, Objects in Motion

Read through the entire activity on page 276 of the textbook.

Follow the instructions outlined in "What to Do." You can use any suitable wheeled toy and plastic figurine for this activity. For example, a toy wagon and a doll will work fine.

8. Answer questions 1 and 2 of "What Did You Find Out?"

CHECK Check your answers on page 126 of the Appendix.

You should now have a good understanding of impulse and its relationship to changing the momentum of a moving object. Do the following to check what you covered in this lesson.

9. Answer questions 1 to 5 of "Check Your Understanding," on page 276 of the textbook.

CHECK Check your answers on page 127 of the Appendix.

Go to ... Go to pages 2 and 3 of Assignment Booklet 4B and answer questions 7 to 10.

Lesson 3

Changing Momentum Quickly

[1]

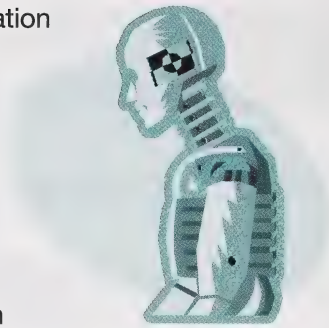
Crash tests form a critical component of designing safer vehicles. These tests also provide consumers important information as to how competing vehicles compare in protecting drivers and passengers. If you have seen slow-motion video clips of these tests, you likely noticed that at high speeds, once the front of the vehicle strikes the barrier and stops, the back of the vehicle continues to move forward. The tremendous forces released as the vehicle's momentum changes abruptly buckles the front end in a fraction of a second. Seat belts and air bags help protect occupants as they fly forward at the original speed of the vehicle.

To see a short movie of a frontal collision, insert the *Science 24 Multimedia* CD into your computer. View the segment "Changing Momentum Quickly: Frontal Crash Test."

In this lesson you will examine what happens when momentum changes quickly.

[1] Source: *Collision Testing, Transport Canada 2004*. Reproduce with the permission of the Minister of Public Works and Government Services Canada, 2004.

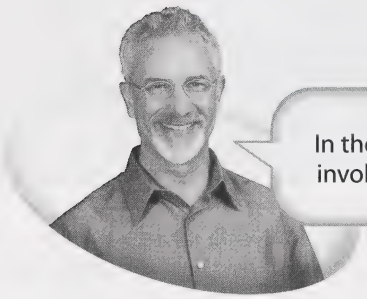
Turn to page 277 of the textbook and read the information in "Changing Momentum Quickly." Study Figure 15.7 closely.



1. Figure 15.7 compares a slow, safe stop from a speed of 100 km/h to a collision into a brick barrier at the same speed. What three factors are the same in both incidents?

2. Answer the question posed in "Reading Check" on page 277 of the textbook.

Check your answers on page 127 of the Appendix.



In the next part of this lesson you will calculate the forces involved when impulse occurs and momentum changes.

Turn to page 278 of the textbook and work through "Math Connect: Calculating Force." Use the procedures outlined in the sample problem to answer the questions that follow. Notice that the force is negative since it is used to slow the vehicle.

3. Answer questions 1, 2, and 3 of "Solve These" on page 278 of the textbook.

4. Answer the question posed in Figure 15.7 at the bottom of page 277. Car B was used in the calculation in question 1.a. on page 278. Car A was used in the sample problem on page 278.

Check your answers on pages 128 and 129 of the Appendix.

In the next investigation, you will examine collision damage.

Investigation

15-A: Collision Damage

Read the entire investigation on page 279 of the textbook.

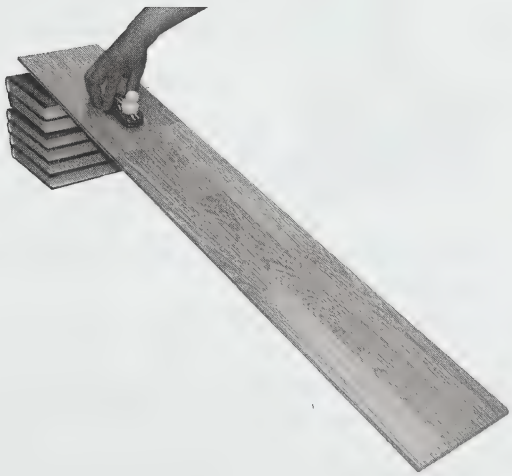
Here's a recipe you can use to make playdough to build your passenger.

PLAYDOUGH

- 125 mL ($\frac{1}{2}$ cup) salt
- 250 mL (1 cup) flour
- 10 mL (2 tsp) cream of tartar
- 250 mL (1 cup) water
- 15 mL (1 tbsp) vegetable oil
- food colouring

Mix salt, flour, and cream of tartar together. Add water, oil, and food colouring. Place in a saucepan on very low heat, and stir until mixture turns rubbery. Remove from heat and knead. Keep the playdough in a container in the refrigerator.

Follow the steps of the procedure carefully. Measure the distances the passenger flies carefully. Also, describe the damage to the model in detail and reshape the model after each collision.

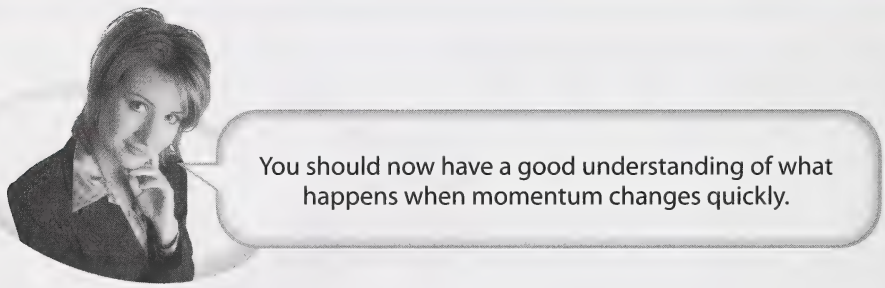


5. Complete a table similar to the following to record your observations.

Starting Point: Distance up Ramp	Light Barrier		Heavy Barrier	
	Distance from Barrier to Landing Point	Damage to Passenger	Distance from Barrier to Landing Point	Damage to Passenger
25 cm				
50 cm				
100 cm				

6. Answer questions 1, 2, and 3 of "Analyze."

CHECK Check your answers on pages 129 and 130 of the Appendix.



7. Answer questions 1, 2, and 3 of "Check Your Understanding," on page 280 of the textbook.

CHECK Check your answers on pages 130 and 131 of the Appendix.

Go to ... Go to pages 3 and 4 of the Assignment Booklet 4B and answer questions 11 to 16.

Lesson 4

Is Momentum Lost?

You are stopped at a red light waiting for it to change. It is early winter, and the snow has been falling steadily for an hour, making the intersections very slick. You look in the rear-view mirror and see a car sliding towards your car. Next thing you know, you feel the jolt of the collision and the two vehicles lock together. Your car begins to slide forward on the ice into the intersection. Fortunately, cross traffic is light and your vehicle doesn't get hit from the side. Unfortunately, this type of collision is all too common when roads are icy and drivers do not adjust to the icy conditions.

In the collision, some of the momentum of the vehicle that hit your vehicle transferred to your vehicle. Of course, friction slows both vehicles to a stop; but immediately after the accident, how did the momentum of the two vehicles moving forward compare to the momentum of the car immediately before it hit your car?

In this lesson you will explore the total momentum of two objects just before and just after they collide.

Turn to pages 280 and 281 of the textbook. Read the introduction to "Is Momentum Lost?" and the discussion in "Conservation of Momentum." Study Figure 15.8 closely.

1. What happens to energy of movement when momentum is lost?

2. A car rear-ends another car travelling in the same direction.

   a. Which car experiences a negative force? Explain your answer.

   b. Which car experiences a positive force? Explain your answer.

3. What does the Law of Conservation of Momentum tell you about the momentum immediately before and after a collision.

CHECK

Check your answers on page 131 of the Appendix.

Law of Conservation of Momentum

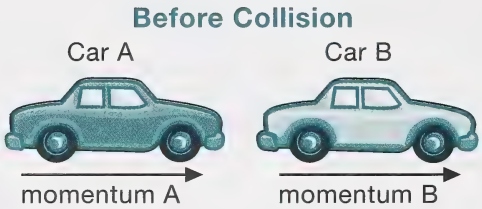
The total momentum of two objects immediately after a collision is the same as the total momentum of the two objects immediately before the collision.

Example

Reread the scenario at the beginning of this lesson—the one in which you were rear-ended at an icy intersection. Suppose each vehicle had a mass of 1000 kg and the vehicle hit you going 5 km/h. How fast were both vehicles travelling immediately after the collision?

Solution

Calculate the total momentum before the collision.



$$\text{momentum of approaching car} = \text{mass} \times \text{velocity}$$
$$= 1000 \text{ kg} \times 5 \text{ km/h}$$
$$= 5000 \text{ kg} \cdot \text{km/h}$$

$$\text{momentum of your car} = \text{mass} \times \text{velocity}$$
$$= 1000 \text{ kg} \times 0 \text{ km/h}$$
$$= 0 \text{ kg} \cdot \text{km/h}$$

$$\text{total momentum before collision} = 5000 \text{ kg} \cdot \text{km/h} + 0 \text{ kg} \cdot \text{km/h}$$
$$= 5000 \text{ kg} \cdot \text{km/h}$$

By the Law of Conservation of Momentum, the total momentum immediately after the collision is also 5000 kg•km/h.

After Collision

Car A slows down, thus losing momentum.

Car B speeds up, thus gaining momentum.

momentum A $- x$ momentum B $+ x$

The combined mass of the vehicles is 2000 kg. Treat this mass as a single object travelling at velocity v.

total momentum after collision = mass × velocity

$$\text{velocity} = \frac{\text{total momentum after collision}}{\text{mass}}$$

$$v = \frac{5000 \text{ kg•km/h}}{2000 \text{ kg}}$$

$$v = 2.5 \text{ km/h}$$

After the collision, both vehicles were travelling 2.5 km/h.

4. Suppose your stopped, 1000-kg car had been hit from behind by a 2000-kg truck travelling 5 km/h. How fast did the truck and your car travel after the collision? Again, assume the truck and your car lock together.

Check your answer on page 132 of the Appendix.

Next, see what happens when two vehicles collide head on. Turn to page 281 of the textbook and read "Head-on Collisions." Carefully examine Figure 15.9.

5. In Figure 15.9, why does Car A have a positive momentum and Car B a negative momentum?

6. Answer the question posed in "Reading Check" on page 281 of the textbook.

7. Answer "Try This!" on page 281 of the textbook. Describe what happens in each situation.

Check your answers on pages 132 and 133 of the Appendix.

To explore what happens when two objects collide and stick together, insert the *Science 24 Multimedia* CD. Launch the applet "Conservation of Momentum: Two-Mass, Inelastic Collision." When using this applet, set the coefficient of restitution to 0. With this setting, when the red object (M1) and blue object (M2) collide, they will not bounce apart; they will stick together. You can change the mass of each object, and you can change the velocity of each object. Click on "Update" to have the changes take effect if you entered them manually. Remember, a positive velocity will make the object travel to the right and a negative velocity will make the object travel to the left.

Use this applet to answer questions 8 to 11.

8. Assign M1 a mass of 10 kg and a velocity of +5 units. Assign M2 a mass of 10 kg and a velocity of 0 units. Describe what happens before and after the collision.

9. Assign M1 a mass of 10 kg and a velocity of +5 units. Assign M2 a mass of 10 kg and a velocity of +2 units. Describe what happened before and after the collision.

10. Assign M1 a mass of 10 kg and a velocity of +5 units. Assign M2 a mass of 10 kg and a velocity of −5 units. Describe what happened before and after the collision.

11. Assign M1 a mass of 10 kg and a velocity of +5 units. Assign M2 a mass of 40 kg and a velocity of −5 units. Describe what happened before and after the collision.

Check your answers on page 133 of the Appendix.

You will use the results from questions 8 to11 to help you analyze collisions described in the next investigation.

Investigation

15-B: Momentum Changes in a Collision

Read the entire investigation on page 282 of the textbook.

Follow the steps of "What to Do" carefully.

12. Answer questions 1 to 4 of "Analyze."

CHECK Check your answers on pages 133 and 134 of the Appendix.

You should now have a good understanding of what happens in a collision. You will now apply the Law of Conservation of Momentum to analyze collisions.

Turn to page 283 of the textbook and work through the sample problem in "Math Connect: Calculating Final Momentum."

13. Answer question 1 of "Solve This" on page 283 of the textbook.

14. Answer question 2 of "Check Your Understanding" on page 283 of the textbook.

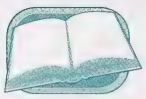
CHECK Check your answers on pages 134 and 135 of the Appendix.

Go to ... Go to pages 5 and 6 of Assignment Booklet 4B and answer questions 17 to 21.

Section 3 Review

In this section you explored the physics of collisions. You investigated momentum and how momentum is related to mass and velocity. To change an object's momentum, you discovered you had to exert a force—either a small force over a long time or a large force over a small time. You discovered that abrupt changes in momentum occur in vehicle accidents. You then analyzed collisions by applying the Law of Conservation of Momentum.

Even though this unit emphasized what happens to vehicles and their occupants during vehicular collisions, you can apply the physics of collisions in a variety of contexts. Many such applications occur in sports. Think of soccer, for instance. When a person kicks a ball, there is an abrupt change in its velocity and momentum. You can also think of hockey. How is it possible to send a puck hurtling towards the goal just by applying a force to your hockey stick?



You have now completed the concepts for this section. To review what you covered, do the following " Chapter 15 Review" questions on pages 284 and 285 of the textbook. If necessary, go back and read over parts of this section as you answer the questions.

1. Answer questions 1, 2, and 3 of "Reviewing Key Terms."

2. Answer questions 4 and 6 of "Understanding Key Ideas."

3. Answer questions 10 and 11 of "Problem Solving/Applying." **Note:** It is not necessary to draw a diagram for question 10.

4. Answer question 13 of "Critical Thinking."

Check your answers on pages 135 to 137 of the Appendix.

Section 4

THE TECHNOLOGY OF SAFETY

Every parent wants the best for their children. Few, if any, would knowingly put their children in danger. But, transporting an infant in a vehicle, without using an infant car seat that is anchored securely to a seat in the back, places the child at risk for injury or death! The Ontario Ministry of Transportation reports that infant car seats reduce injury by 75% in the event of an accident. However, they also estimate that 80% of infant car seats are used incorrectly! Are you aware of how infant car seats should be used?

Safety issues are not only important for children. Everybody, both drivers and passengers, has a responsibility for their safety and the safety of others. Do you always wear a seat belt? Have you ever ridden in a vehicle with more passengers than seat belts?

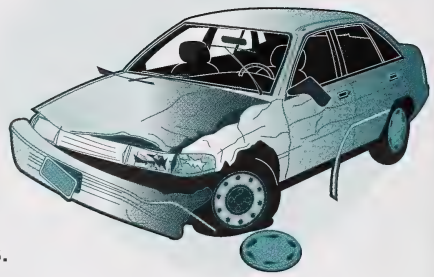
In this section you will explore the safety features of modern vehicles and highways. You will investigate how seat belts and airbags operate and their proper use and maintenance.

Turn to pages 286 and 287 of the textbook and read the introduction to "Chapter 16: The Technology of Safety." After reading the introduction, read "Science Log." Think about the questions asked. Also, read over the points in "What You Will Learn," "Why It Is Important," and "Skills You Will Use" on page 287. These provide a brief overview of what will be covered in this section.

Lesson 1

How Safety Features Work

When you view crash tests and see brand new vehicles deliberately destroyed by smashing them into barriers, do you question the economics of these tests? As expensive as these tests are, they form a critical part of vehicle design. Crash tests and the effects of these collisions on crash test dummies provide engineers with invaluable information about safety features they design to protect drivers and passengers.



In this lesson you will analyze how safety features in automobile and highway designs work. But, first, you will look at some of the more recent changes in vehicle design that have improved vehicle safety.

Starting Point Activity

Safety Systems over Time

Read the entire activity on page 287 of the textbook. **Note:** You do not need to work in a team of two or three for this activity.

1. Answer question 2 of "What to Do." In addition to examining the visuals, you will need to think about what you know about today's vehicles. You may wish to pick up a vehicle brochure from a car dealer in your area.

CHECK Check your answer on page 138 of the Appendix.

Turn to page 288 of the textbook and read the introduction to "How Safety Features Work."

2. What is the role of the safety engineer in vehicle design?

3. What is the basic idea behind most vehicle safety features?

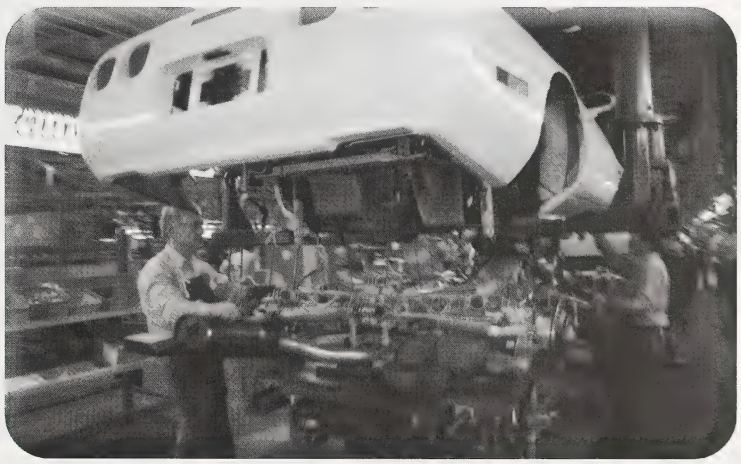
4. What information do engineers obtain from crash test dummies?

5. What parts of a car are usually the **crumple zones**? What is the purpose of crumple zones?

crumple zone: an area of a vehicle that is designed to collapse and absorb energy in a collision

Check your answers on page 138 of the Appendix.

In the next part of this lesson you will explore different types of safety features in vehicle design. Turn to page 289 of the textbook and read "Types of Safety Features."



6. Identify what is included in each of these categories.

   a. restraining features

   b. operational features

   c. structural features

Check your answers on page 138 of the Appendix.

Turn to page 290 of the textbook and read the discussion of "Safety Features at Work."

7. Why did older cars not absorb much of the impact in a collision?

8. Why do modern engineering designs use lighter, bendable materials like fibreglass and aluminum?

9. Which parts of a modern vehicle are made of rigid materials? Explain the reasons for their rigid design in each case.

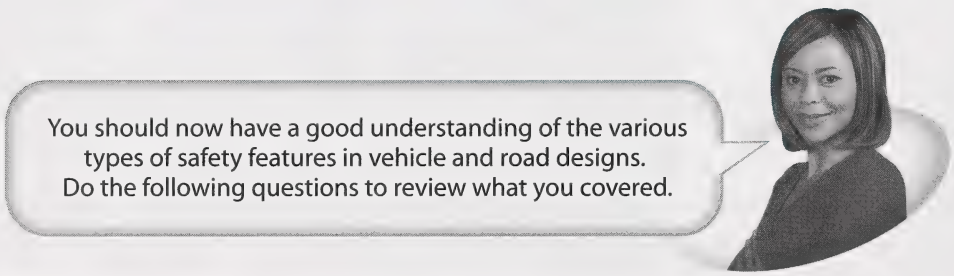
Check your answers on pages 138 and 139 of the Appendix.

Not all safety features are in vehicles. Some are built into the roads vehicles travel along. Turn to page 291 of the textbook and read "Road Safety Features."

10. How do road safety features reduce the force of a collision?

11. Describe three road safety features and how they work.

Check your answers on page 139 of the Appendix.


You should now have a good understanding of the various types of safety features in vehicle and road designs.
Do the following questions to review what you covered.

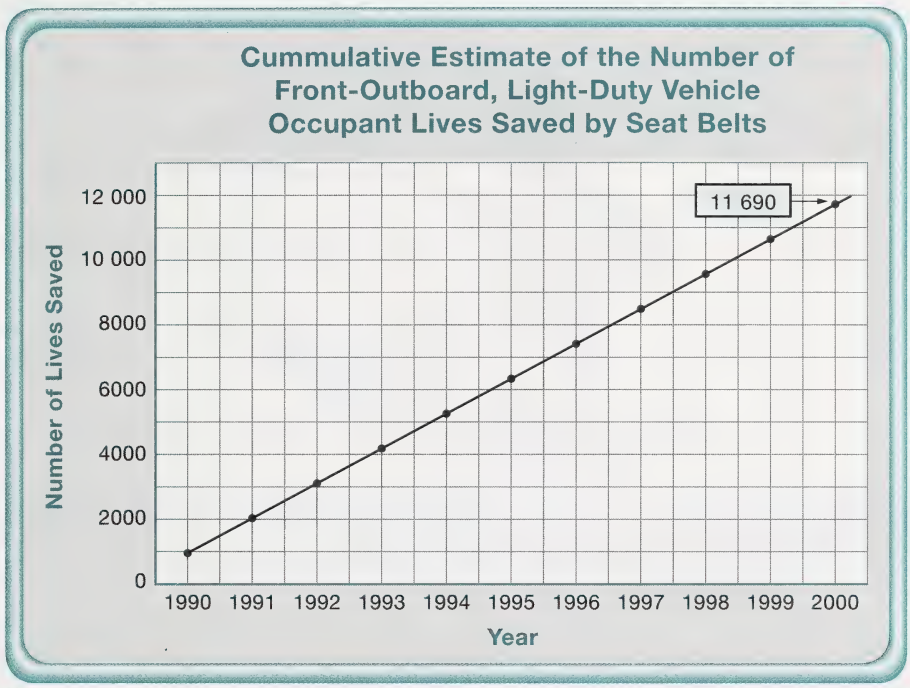
12. Answer questions 1 and 4 of "Check Your Understanding" on page 291 of the textbook.

Check your answers on page 139 of the Appendix.

Go to pages 7 and 8 of Assignment Booklet 4B and answer questions 1 to 6.

Lesson 2

Seat Belts



SOURCE: TRANSPORT CANADA

Statistics support the use of seat belts! Transport Canada estimates that between 1990 and 2000, approximately 11 690 Canadians owe their lives to wearing a seat belt! This number is more than the entire population of Banff, Alberta. Compliance with seat belt laws is roughly 90%, but the 10% who don't still represents too many drivers and passengers on the road who unnecessarily put their lives at risk!

For more recent statistics and important information on traffic and vehicle safety, visit Transport Canada's website.

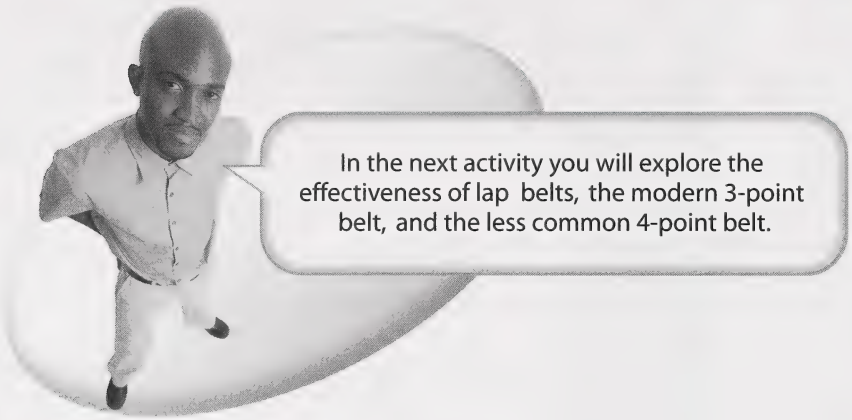
http://www.tc.gc.ca

In this lesson you will investigate how seat belts work and how to properly use them. You will also explore child restraints.

Turn to page 292 of the textbook and read the introduction to "Seat Belts."

1. Answer the questions posed in "Reading Check" on page 292 of the textbook.

Check your answer on page 139 of the Appendix.


In the next activity you will explore the effectiveness of lap belts, the modern 3-point belt, and the less common 4-point belt.

Find Out Activity

Seat Belts Then and Now

Read the entire activity on page 292 of the textbook.

Follow the steps in "What to Do" to complete the activity.

2. Why do you think manufacturers have changed the design of seat belts?

3. What is the benefit of a 4-point seat belt?

Check your answers on page 139 of the Appendix.

In the next part of the lesson you will investigate how modern seat belts work and how they should be worn to be effective. Turn to page 293 of the textbook and carefully read "How Seat Belts Work." Then read "Proper Use of 3-Point Seat Belts" on page 295.

4. What is the material of a seat belt made of?

5. Answer the question posed in "Reading Check" on page 293 of the textbook.

6. Briefly explain how the retractor unit works.

7. When you wear the 3-point belt correctly, where do the straps cross your body?

8. Answer the question posed in "Reading Check" on page 295 of the textbook.

Check your answers on pages 139 and 140 of the Appendix.

In the last part of the lesson you will investigate child restraints.

Investigation

16-B: Little Problems, Big Solutions

Read through the entire investigation on page 296 of the textbook.

Follow the directions in "What to Do" carefully to complete this investigation.

9. Answer questions 1 to 5 of "Analyze."

Check your answers on page 140 of the Appendix.

Read the discussion in "Child Restraints" page 297 of the textbook.

10. Approximately how many children are needlessly injured every year because they are not properly restrained?

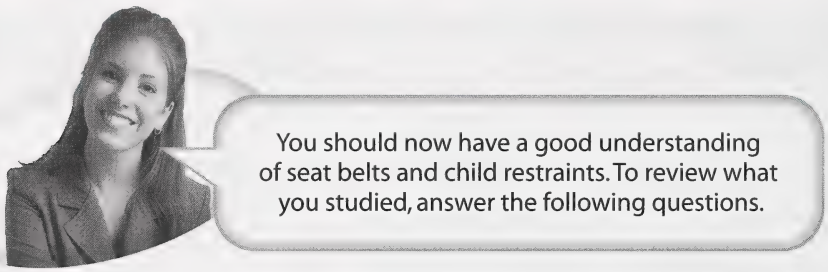
11. Where should children be seated in a car? Why?

12. Explain why infant car seats face toward the back of the vehicle?

13. When should children be moved from an infant car seat to a child seat?

14. Who should use booster seats? Why?

CHECK Check your answers on pages 140 and 141 of the Appendix.


You should now have a good understanding of seat belts and child restraints. To review what you studied, answer the following questions.

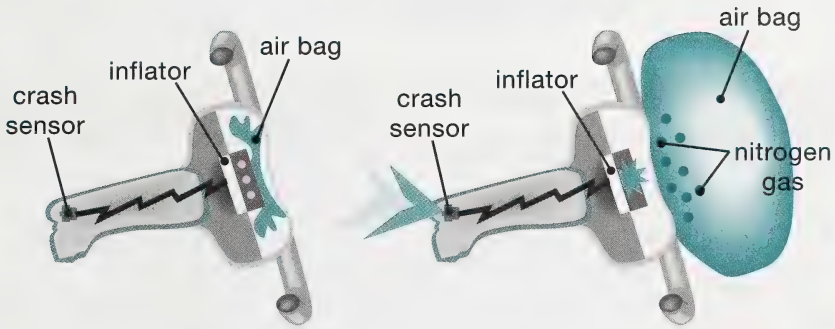
15. Answer questions 2, 4.a., and 5 of "Check Your Understanding" on page 297 of the textbook.

CHECK Check your answers on page 141 of the Appendix.

Go to ... Go to pages 8 and 9 of Assignment Booklet 4B and answer questions 7 to 11.

Lesson 3

The Evolving Air Bag



air bag: an inflatable device for restraining vehicle occupants and absorbing energy in a collision

In Lesson 2 you were shown that thousands of lives in Canada have been saved by seat belts alone. **Air bags** in the front compartment for the driver and passenger have also saved countless others across the world from serious injury, disfigurement, and death. However, the air bag is not intended to be used alone! It is designed to work in conjunction with seat belts. Don't think because your vehicle is equipped with air bags that this gives you an excuse not to wear your seat belt!

In this lesson you will examine air bags—their design and their use.

Turn to page 298 of the textbook and read the introductory paragraphs of "The Evolving Air Bag."

1. How are air bags similar to parachutes?
2. How quickly do air bags inflate?
3. Answer the question posed in "Reading Check."
4. Where are air bags located in most vehicles?
5. Why should small children not be placed in the front passenger seat?

CHECK Check your answers on pages 141 and 142 of the Appendix.

In the next investigation you will explore how air bags protect when they are properly inflated.

Investigation

16-C: This Is You . . . This Is You in a Crash

Read through the entire investigation on page 299 of the textbook.

Carefully follow the steps in "What to Do" to complete the investigation. **Pay special attention to the safety precautions mentioned.**

6. Answer questions 1 to 4 of "Analyze."

CHECK

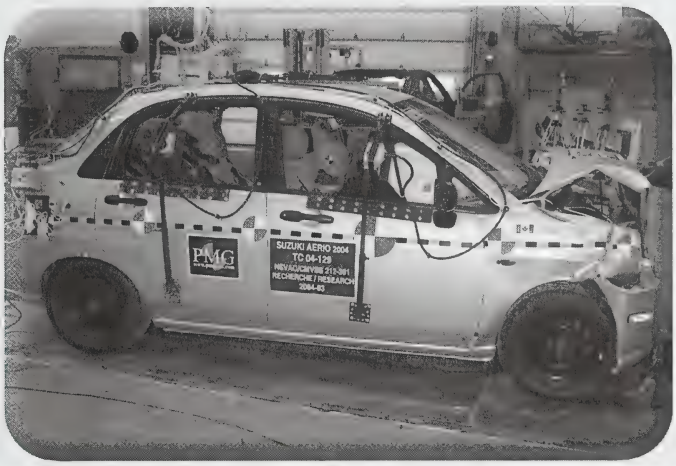
Check your answers on page 142 of the Appendix.

In the next investigation you will try your hand at designing a safety feature to protect vehicle occupants.

Investigation

16-D: Future Safety Technology

Read through the entire investigation on page 300 of the textbook.



[1]

Read the suggestions in "Design Criteria," and follow the instructions in "Plan and Construct" carefully.

7. Answer question 1 of "Evaluate." **Note:** A diagram is not necessary.

Check your answer on page 142 of the Appendix.

[1] Source: *Collision Testing, Transport Canada 2004*. Reproduce with the permission of the Minister of Public Works and Government Services Canada, 2004.

Now, read "Safety Systems Continue to Improve" on page 301 of the textbook.

8. Describe some of the features of third generation air bags.

9. Answer the question posed in "Reading Check" on page 301 of the textbook.

10. How many times more have people been saved by air bags than have been killed by them?

Check your answers on page 142 of the Appendix.

You should now have a good understanding of how air bags save lives and help prevent injuries. Do the following to review what you have covered.

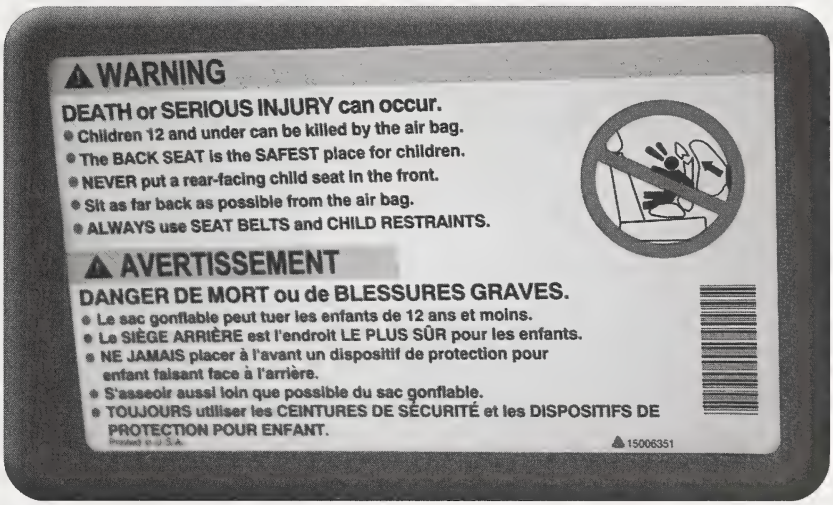
11. Answer questions 1 to 5 of "Check Your Understanding," on page 301 of the textbook.

Check your answers on page 143 of the Appendix.

Go to page 9 of Assignment Booklet 4B and answer questions 12 to 14.

Section 4 Review

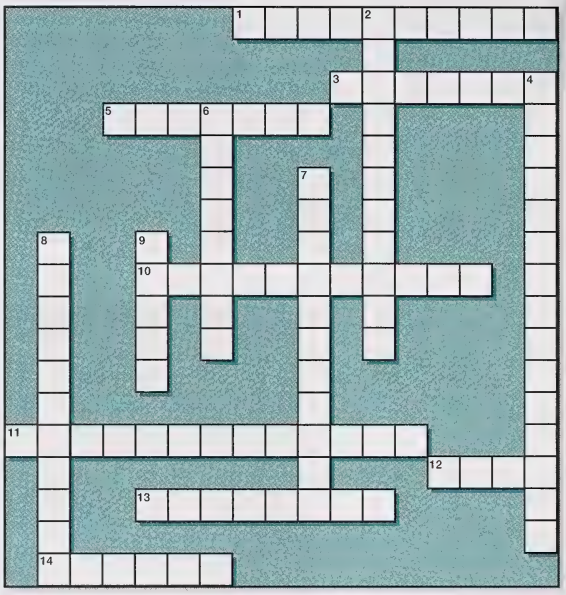
In this section, you explored how vehicle safely features employ the laws of physics to protect occupants of vehicles involved in traffic accidents. In particular, you investigated seat-belt and air-bag designs. You also studied the design and use of infant car seats, child seats, and booster seats for transporting children safely.


⚠ WARNING
DEATH or SERIOUS INJURY can occur.
• Children 12 and under can be killed by the air bag.
• The BACK SEAT is the SAFEST place for children.
• NEVER put a rear-facing child seat in the front.
• Sit as far back as possible from the air bag.
• ALWAYS use SEAT BELTS and CHILD RESTRAINTS.
⚠ AVERTISSEMENT
DANGER DE MORT ou de BLESSURES GRAVES.
• Le sac gonflable peut tuer les enfants de 12 ans et moins.
• Le SIÈGE ARRIÈRE est l'endroit LE PLUS SÛR pour les enfants.
• NE JAMAIS placer à l'avant un dispositif de protection pour enfant faisant face à l'arrière.
• S'asseoir aussi loin que possible du sac gonflable.
• TOUJOURS utiliser les CEINTURES DE SÉCURITÉ et les DISPOSITIFS DE PROTECTION POUR ENFANT.
15006351

One of the recommendations parents should follow when transporting infants and toddlers is to secure infant seats and child seats in the back seat of their vehicle. Car manufacturers, like General Motors and Ford, are doing their part in getting the word out. For the past few years they have attached the warning shown in the photograph on both sun visors in the front seats of their vehicles. What would you do if you noticed anyone who is unaware of this hazard?

You have now completed the concepts for this section. To further your understanding, do the questions that follow. If necessary, go back and read over parts of this section as you answer the questions.

1. Complete the following puzzle.



Across

1. A roll cage is an example of this type of safety feature.
3. used in crash tests to simulate people
5. first generation seat belt
10. Brakes are an example of this type of safety feature.
11. barrels filled with water or sand that burst or crush on impact (2 words)
12. When infants are more than this weight (in kilograms), they should be moved into a car seat.
13. the gas used to inflate air bags
14. the number of milliseconds in which an air bag inflates

Down

2. a part of a vehicle that collapses and absorbs energy in a collision (2 words)
4. second generation seat belts (2 words)
6. where children should ride in a car (2 words)
7. A seat belt is an example of this type of safety feature.
8. what an older child should use in order to wear a shoulder harness properly (2 words)
9. Safety features are designed to reduce this.

2. Answer the following "Chapter 16 Review" questions on pages 302 and 303 of the textbook.

   a. questions 2 to 6 of "Understanding Key Ideas"

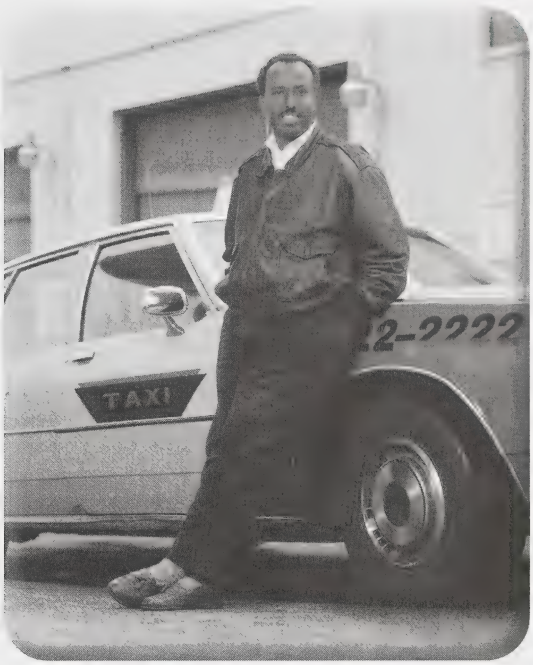
   b. questions 7 and 8 of Developing Skills"

   c. questions 11 and 13 of "Problem Solving/Applying"

   d. question 15 of "Critical Thinking"

Check your answers on pages 143 to 145 of the Appendix.

Module Summary



In this module you learned that there is a greater risk of being injured or killed while travelling in a vehicle than in other everyday activities. Based on this risk, you investigated some of the safety systems and practices government and the transportation industry have adopted and are currently exploring to protect drivers and their passengers.

Throughout this module, you explored the underlying science that explains how injuries and deaths occur in accidents and how this science can be used in safety features, such as auto and road design, to prevent casualties. This science included discussions of momentum, forces, impulse, and time factors. You also explored some of the positive actions drivers can take to reduce risks to themselves and others on the road.

Cab drivers—people who transport passengers every day—are well aware of the risks of the road and the huge responsibility they have for their passengers' safety. By driving defensively and constantly staying alert, they reduce risks. By maintaining their vehicles and adopting modern safety practices, they can drive with greater peace of mind! Every driver on the road should take their responsibilities as seriously as these professional drivers!

Congratulations!

You have completed all four modules of

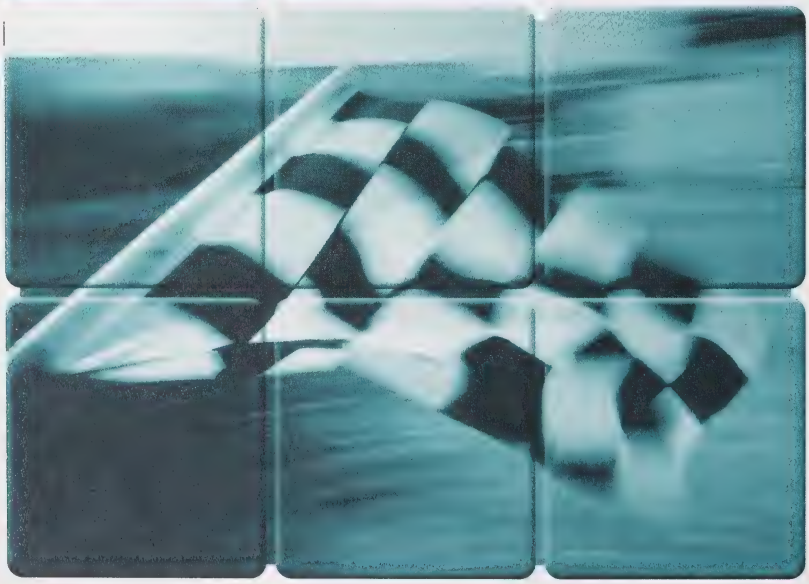
SCIENCE 24!

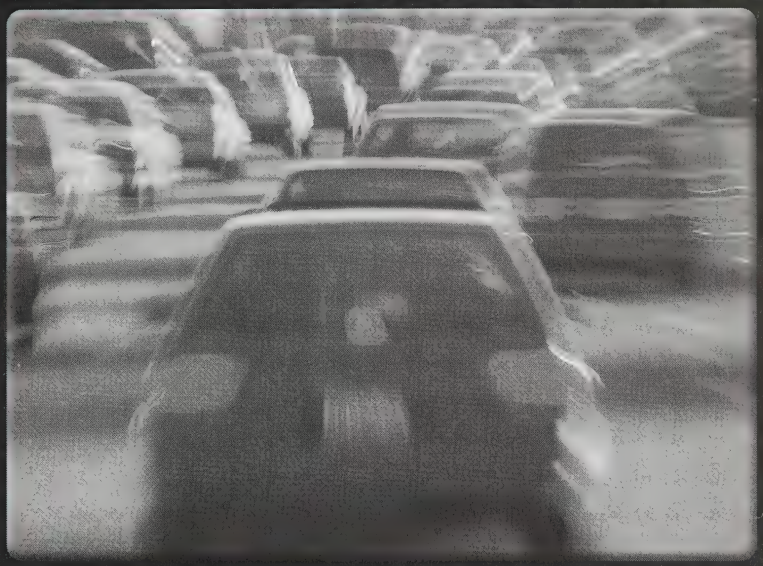
MODULE 1
▪ MATTER AND CHEMICAL CHANGE ▪

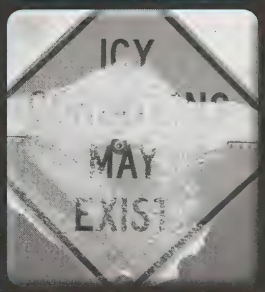
MODULE 2
▪ ENERGY TRANSFORMATIONS ▪

MODULE 3
▪ DISEASE DEFENCE AND HUMAN HEALTH ▪

MODULE 4
▪ SAFETY IN TRANSPORTATION ▪







APPENDIX ■

GLOSSARY ■ SUGGESTED ANSWERS ■ IMAGE CREDITS

Glossary

air bag: an inflatable device for restraining vehicle occupants and absorbing energy in a collision

blood alcohol concentration (BAC): the number of milligrams of alcohol in a millilitre of blood

braking distance: the distance travelled by a vehicle from the time the brakes are applied to the time the vehicle stops

crash cushion: a set of barrels filled with sand or water that acts as a barrier and absorbs energy in the event of an accident

crumple zone: an area of a vehicle that is designed to collapse and absorb energy in a collision

depressant: a substance that slows reactions

first generation seat belt: a lap belt or two-point belt

force: a push or a pull

friction: the force that resists motion when two objects rub against each other

impulse: a measure of force acting over time

Law of Conservation of Momentum: a law stating that the total momentum of objects immediately before a collision equals the total momentum of these objects immediately after the collision

manipulated variable: the variable changed by a researcher in an experiment

momentum: a measure of the motion of an object and the tendency of that object to remain in motion

operational feature: a feature of a vehicle that operates to keep you safe

e.g., brakes, headlights

reaction time: the time it takes to recognize a problem and act on it

responding variable: the variable measured in an experiment by a researcher as a result of changes made to the manipulated variable

restraining feature: a device that holds an occupant in a vehicle in place

rise: the vertical distance between two points on a graph

run: the horizontal distance between two points on a graph

slope: the ratio of rise over run

stimulant: a substance that speeds up reaction time

stopping distance: the distance travelled during a driver's reaction time plus the braking distance

structural feature: a rigid feature and crumple zone built into a vehicle

trauma: physical or emotional stress arising from a motor vehicle collision

variable: a quantity that can change

velocity: speed; rate of change of position

whiplash: the spraining of neck muscles and ligaments

Whiplash is often a result of a motor vehicle collision.

Suggested Answers

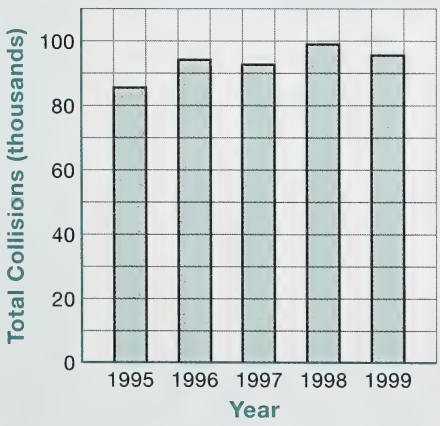
Section 1: Lesson 1

1. **Textbook question "Reading Check," p. 234**

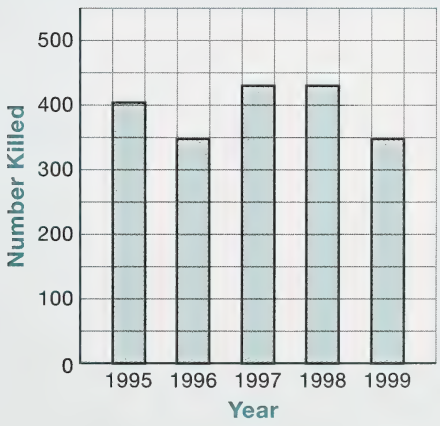
   You are 50 times more likely to die in a car accident than in a plane crash. Also, in Canada, you are 5 times more likely to die in a car accident than be murdered.

2. The sad thing about the high number of traffic collisions in Canada is that almost all are preventable.

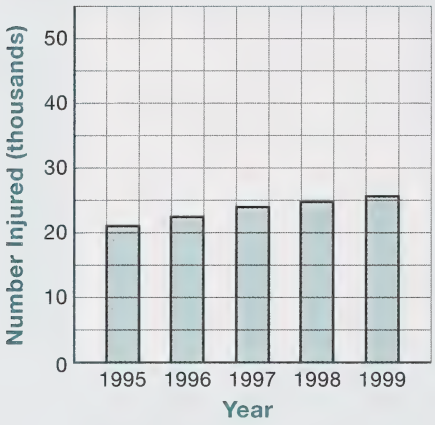
3. **Total Traffic Collisions in Alberta**



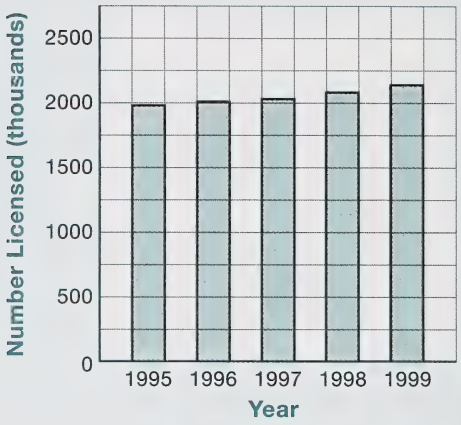
Number Killed in Traffic Collisions in Alberta



Number Injured in Traffic Collisions in Alberta



Number of Licensed Drivers in Alberta



4. **Textbook questions 1, 2, and 3 of "What Did You Discover?," p. 233**

    1. Total collisions and the number injured are increasing. The total deaths has fluctuated over the five-year period.

    2. Total collisions and injuries may have increased because there are more drivers on the road. Fatalities may have stayed the same because of safer vehicles or because of an increase in seat belt use.

    3. Answers may vary. Reasons why the number of injuries due to collisions are increasing may include the following:

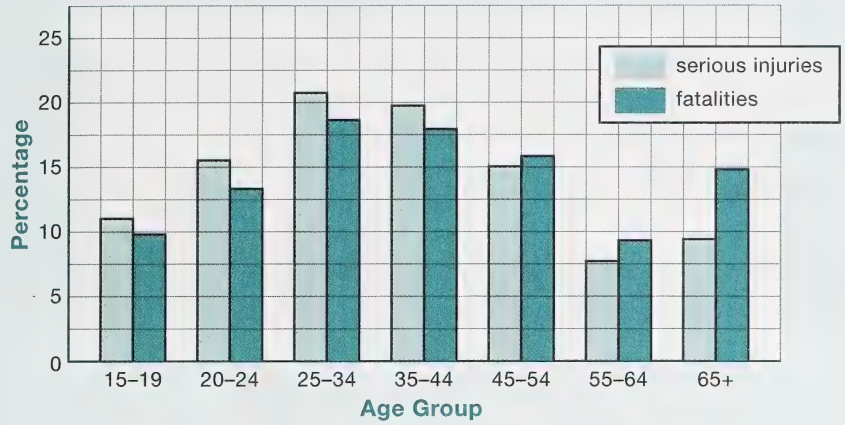
        - There are more licensed drivers, thus more collisions.
        - Drivers may be travelling at higher speeds than in the past.
        - There may be an increase in traffic congestion, leading to more collisions.
        - Drivers may not be following the rules of the road, resulting in more collisions.

5. **Textbook questions 1 to 6 of "What Did You Find Out?," p. 235**

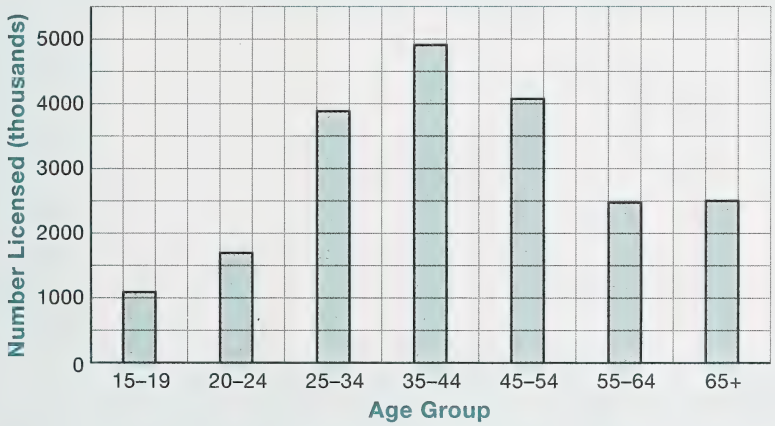
    1. a. The 25–34 age group has the highest percentage of serious injuries and fatalities. The 55–64 age group has the lowest percentage of serious injuries and fatalities.

        b. There may be more inexperienced and aggressive drivers in the 25–34 age group. Drivers in the 55–64 age group are more experienced drivers and may be more cautious and defensive drivers.

2. a. **Percentage of Driver Injuries and Fatalities, by Age Group (2000)**



Number of Licensed Drivers



b. The 25–34 age group should have the highest insurance rates. The 55–64 age group should have the lowest insurance rates. However, if you determine the percentage of licensed drivers in each age group to their respective percentage of injuries and fatalities, you will see that some groups have a much higher percentage of injuries and fatalities than their portion of the total number of licensed drivers.

3. The four most common causes of death for Canadians are cancer, heart and blood system diseases, injuries and poisonings, and respiratory diseases. **Note:** The other causes category has a higher number of deaths, but it is made up of a number of different causes.

4. Cancer and heart and blood system diseases appear to be decreasing overall. This fact may be due to improved health care and advances in medicine.

5. a. You can take action to prevent death from cancer, heart and blood system diseases, respiratory diseases, chronic liver diseases, injuries and poisonings, motor vehicle accidents, and suicide.

   b. Answers may vary. Sample answers are given.

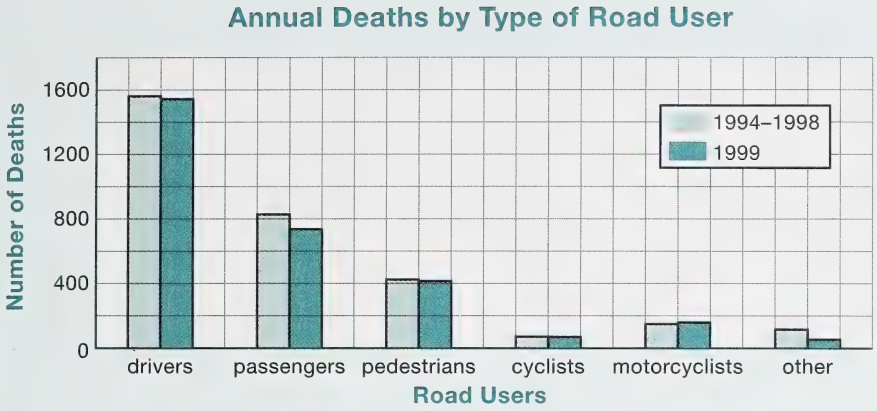
Cause of Death	Preventative Action
cancer	• no smoking • eating a proper diet
heart and blood system diseases	• no smoking • exercising • eating a proper diet
respiratory diseases	• no smoking
chronic liver diseases	• hepatitis vaccines • avoiding excess alcohol consumption
injuries and poisonings	• following safety precautions • proper product labelling • proper product storage
motor vehicle accidents	• driving defensively • wearing seat belts
suicide	• seeking counselling • applying mental health measures

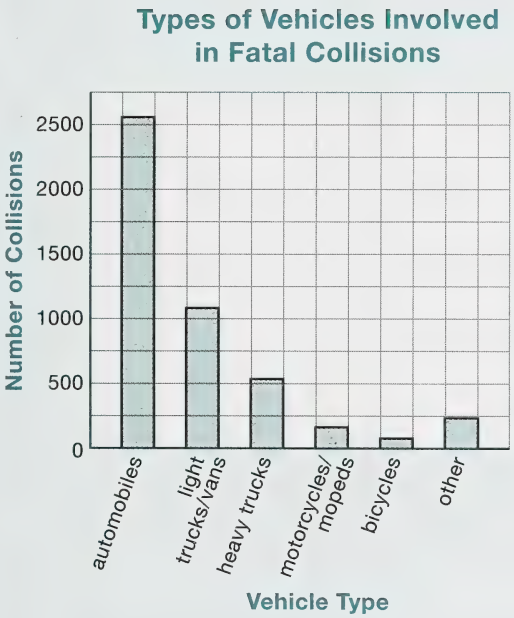
6. a. Answers may vary. A sample answer is given.

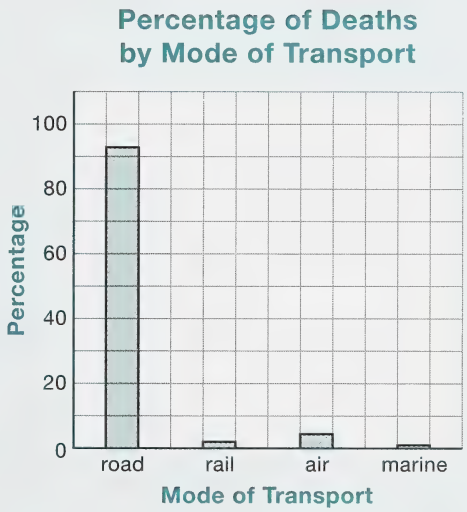
   Cancer, diabetes, heart and blood system diseases, respiratory diseases, and chronic liver diseases would likely be more common causes of death for elderly people.

   b. Injuries and poisonings, motor vehicle accidents, and suicides would likely be more common causes of death for teenagers.

6.







7. **Textbook questions 1 to 4 of "How Safe Are You?," p. 236**

1. Automobiles have the most accidents. This is because there are more automobiles on the road than any other type of vehicle.

2. More than twice as many motorcyclists have died compared to cyclists because they

   - travel at higher speeds
   - travel with faster-moving traffic
   - travel among other vehicles rather than on the shoulders of roads

3. Twice as many drivers as passengers have died because sometimes there are no passengers in the vehicles. Also, in an accident, drivers are more prone to injuries because of the close proximity of the steering wheel (injuries caused by hitting the steering wheel).

4. Road travel accounts for the largest percentage of transportation fatalities.

8. **Textbook question "Reading Check," p. 235**

   Types of injuries that could arise from vehicle accidents are cuts, bruises, and broken bones; whiplash; serious burns; internal injuries; and head and spinal injuries that may lead to blindness, paralysis, or brain damage.

9. Possible reasons more vehicle accidents happen on Friday may include the following:

   - People are tired at the end of the work week.
   - People may be in a rush after work to get to cabins, lakes, or weekend getaways.
   - People may indulge in alcohol more often on Friday.

10. **Textbook questions 2 and 3 of "Check Your Understanding," p. 236**

    2. Answers will vary. A sample answer is given.

       Factors that affect safety on Canada's roads include

       - icy conditions
       - drivers not paying attention
       - not driving defensively
       - fog, rain, snow, or darkness affecting visibility
       - driver attitude
       - mechanical conditions of vehicles

    3. Road travel is the least safe mode of transportation. The percentage of deaths on the road is about 92.6%. The other modes of transportation, together, make up the remaining 7.4%.

Section 1: Lesson 2

1. **Textbook question "Reading Check," p. 237**

   Reaction time is the time it takes you to recognize a problem and act on it. Reaction time is important to drivers because time is critical in avoiding accidents. For example, if your reaction time is 0.7 s and your vehicle is travelling 110 km/h (about 30 m/s), your car will travel 21 m before you can act.

2. For a given speed, the longer your reaction time is, the farther your vehicle will travel before you can act to avoid a problem.

3. Distractions can slow your reaction time significantly! If your mind is on something else or if you are reaching for something and not in a position to act quickly, your reaction time will be longer.

4. **Textbook questions 1 and 2 of "Prediction," p. 238**

   1. Answers will vary. You may have predicted 5 cm to 30 cm.

   2. Answers will vary. You may have predicted that distractions will increase the distance the metre-stick falls.

5. Your completed tables should be similar to the following.

PART 1: REACTION TIME

Person	Trial				Average
	1	2	3	4	
1	16 cm	17 cm	20 cm	16 cm	17 cm
2	19 cm	17 cm	16 cm	17 cm	17 cm

PART 2: REACTION TIME WITH DISTRACTIONS

Step	Person	Trial				Average
		1	2	3	4	
8	1	17 cm	18 cm	19 cm	20 cm	19 cm
	2	26 cm	25 cm	19 cm	19 cm	22 cm
9	1	17 cm	22 cm	20 cm	20 cm	20 cm
	2	25 cm	26 cm	18 cm	24 cm	23 cm
10	1	18 cm	19 cm	26 cm	27 cm	23 cm
	2	31 cm	25 cm	26 cm	26 cm	27 cm

PART 3: REACTION TIME WHILE DIALING

Person	Trial				Average
	1	2	3	4	
1	30 cm	37 cm	26 cm	31 cm	31 cm
2	35 cm	36 cm	47 cm	29 cm	37 cm

PART 4: REACTION TIME WITH DIZZINESS

Person	Trial				Average
	1	2	3	4	
1	23 cm	35 cm	28 cm	26 cm	28 cm
2	35 cm	18 cm	22 cm	21 cm	24 cm

a. **Textbook questions 1 to 4 of "Analyze," p. 239**

1. a. Answers will vary. Sample answers are given in the tables.

   b. For steps 8 through 12, as the tasks became more difficult or the distractions increased, the distance the metre-stick dropped increased. Where the reaction time improved with trail numbers, it may be because you increase your concentration on how to catch the metre-stick.

2. a. Your scores for reaction times with distractions will be higher than your base reaction time.

   b. Yes, the complexity of the math did affect reaction time. The more complicated the math was, the longer the reaction time was.

   c. In a car, if the driver is distracted, the time it takes the driver to respond to avoid a problem increases.

   3. Dialing a phone greatly increased reaction time.

4. a. Dizziness greatly increased reaction time.

   b. Dizziness models the effects of a driver on drugs or alcohol.

b. **Textbook question 5 of "Conclude and Apply," p. 239**

5. Some of the distractions that may slow your reaction time while driving include

   - smoking
   - day dreaming
   - tuning a radio
   - using a cell phone
   - eating and drinking
   - engaging in conversation
   - looking at pedestrians or accidents
   - selecting and inserting a CD
   - looking for a street address
   - putting on make-up/combing hair

   You can't eliminate all distractions, but you can control or eliminate many from the preceding list. What measures would you take?

6. Fifteen percent of drivers admitted to falling asleep while driving.

7. An exhausted or sleepy driver is a danger to themselves and to others because they cannot pay enough attention to the road and traffic demands. Like impaired drivers, sleepy drivers

    - may roll their vehicle in a ditch
    - may cross the centre line, causing a head-on collision and most likely death
    - have longer reaction times than alert drivers

8. Initially, coffee speeds up reaction times; but when the effects of this stimulant wear off, drivers are more tired than before drinking the coffee.

9. The only cure for a sleepy driver is to pull off the road to a safe location and sleep.

10. Alcohol is called a depressant because it slows reactions, reduces co-ordination, and makes the drinker sleepy.

11. When alcohol is consumed, it is absorbed from the stomach and small intestine into the bloodstream. The liver breaks it down; but more than one drink overtaxes the liver, and the excess alcohol acts as a poison in your system.

12. Prescription and non-prescription drugs can also impair judgment.

13. *Blood alcohol concentration* (*BAC*) is the number of milligrams of alcohol in 1 mL of blood.

14. A BAC of 0.12 means there are 0.12 mg of alcohol in 1 mL of blood.

15. One drink is defined as 45 mL of hard liquor (40%), 150 mL of wine (11%), or 350 mL of beer (4%). **Note:** The percentage of alcohol in wine and beer will vary. For example, most beer in Canada is 5% alcohol.

16. $450 \div 150 = 3$

    There are three "drinks" contained in 450 mL of wine.

17. Generally, the legal limit of BAC in Canada is 0.08.

18. You do not have to exceed a BAC of 0.08 to be charged with impaired driving. You can be charged with impaired driving if the police officer has reason to believe that your driving ability is impaired by alcohol or drugs. This charge is different than being charged with having a BAC exceeding 0.08.

19. **Textbook questions 1 and 2 of "Solve These," p. 242**

1. **step 1: What do you know?**

   The BAC rate is 0.09.
   Alcohol leaves the body at 0.015 BAC units per hour.
   The legal BAC limit is 0.08.

   step 2: What do you want to find out?

   How long will it take for the drinker to be able to drive legally?

   step 3: How far over the legal limit is the drinker?

   $0.09\ \text{BAC} - 0.08\ \text{BAC} = 0.01\ \text{BAC}$

   The drinker's BAC is 0.01 units over the limit.

   step 4: How long will it take this drinker to get down to the legal limit?

   The body gets rid of 0.015 BAC units per hour.

   $$\frac{0.01\ \text{BAC}}{0.015\ \text{BAC/h}} = 0.67\ \text{h}$$

   If this person does not have anything else to drink, it will take about 0.67 h (40 min) before she can legally drive.

2. **step 1:** The BAC rate is 0.117.
   Alcohol leaves the body at 0.015 BAC units per hour.
   The legal BAC limit is 0.08.

   step 2: How long will it take for Joby to be able to drive legally?

   step 3: $0.117\ \text{BAC} - 0.08\ \text{BAC} = 0.037\ \text{BAC}$

   Joby's BAC is 0.037 units over the limit.

   step 4: $\dfrac{0.037\ \text{BAC}}{0.015\ \text{BAC/h}} = 2.47\ \text{h}$

   If Joby does not have anything else to drink, it will take about 2.47 h before he can legally drive.

20. **Textbook questions 1 to 6 of "Check Your Understanding," p. 242**

    1. Things that increase your reaction time are fatigue, alcohol, drugs, and distractions (e.g., using a cell phone and eating).

    2. Depressants increase reaction time, reduce co-ordination, impair judgment, and make people sleepy.

    3. Drinking stimulants improves reaction time initially. But once the effects wear off, the person is more tired than before.

    4. Using a cell phone increases reaction time, takes your eyes off the road, and takes one hand off the steering wheel reducing control.

    5. a. Yes, any amount of alcohol causes some impairment.

       b. Drivers with any amount of alcohol on their breath can be charged with impaired driving if the police officer has reason to believe their driving ability is impaired. This charge is different than being charged with having a BAC exceeding 0.08.

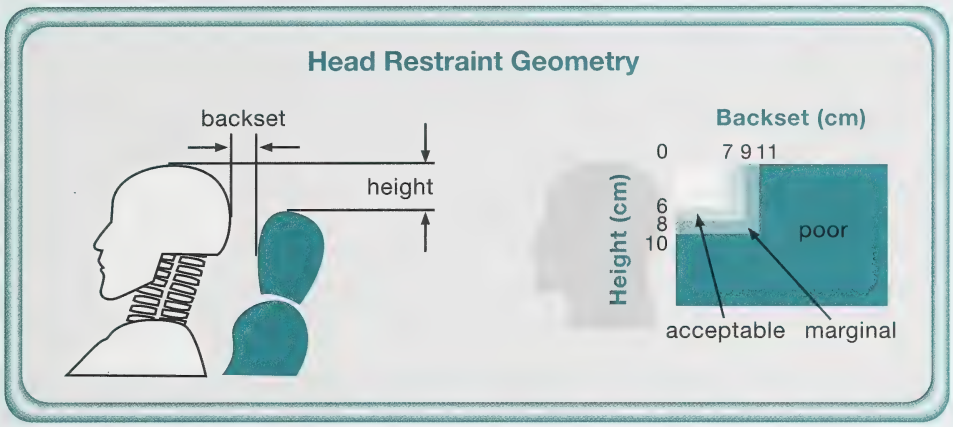
    6. Drinking a soda is not a wise decision while driving because it is a distraction, takes a hand off the steering wheel and can cause the driver to lose control of the vehicle if spilled. Talking to a passenger can cause the driver to take his or her eyes off the road. This can lead to a dangerous situation if some person, object, or vehicle was on the road.

Section 1: Lesson 3

1. Trauma is the physical and/or emotional stress that arises from a motor vehicle collision. Physical traumas include cuts, scrapes, broken bones, whiplash, brain injury, and so on. Emotional traumas involve stress and worry over injuries and other consequences of a collision (such as deaths).

2. **Textbook question "Reading Check," p. 243**

   A headrest helps prevent whiplash by keeping the neck from being bent too far back when the vehicle is hit from behind.



3. The typical symptoms of whiplash are neck pain and stiffness, headaches, tingling and numbness in arms and shoulders, poor concentration, and impaired memory.

4. **Textbook question 1 of "What Did You Find Out?," p. 244**

   1. Those who are involved in vehicle collisions may experience physical and emotional traumas. Therapy may help victims recover from feelings of grief and cope with loss or physical impairment.

5. **Textbook question 2 of "Check Your Understanding," p. 244**

   2. Types of trauma that can be healed include cuts, scrapes, and broken bones. Types of trauma that cannot be healed include brain damage, spinal cord injuries, and amputations.

Section 1: Lesson 4

1. a. Anti-lock braking systems provide better control when braking in slippery conditions.

   b. Crumple zones are designed to absorb some of the energy of a collision.

   c. Side-impact beams prevent doors from caving in as easily in a side collision.

   d. Seat belts restrain occupants so they do not fall out of a vehicle or fly forward into the windshield.

2. People who don't wear seat belts are three times more likely to be injured than people who do wear seat belts.

3. Seat belt use has increased while occupant fatalities have decreased over the years from 1988–1999.

4. Things you should regularly maintain on your vehicle include brakes, tires, steering components, windshield washer fluid, wiper blades, signal lights, and seat belts.

5. When travelling in a motor vehicle, you and all loose objects in the vehicle have inertia (the tendency to keep moving). Seat belts are designed to keep you from flying about in the vehicle, from flying out of an open door/window, or from flying through the windshield in the event of a collision. Seat belts that have a lap belt and a shoulder belt distribute the force over a large area. Seat belts that fit snugly across your lap and shoulder best protect users.

6. Safety features built into roadways include rumble strips, guardrails, breakaway poles and signs, warning lights, interchanges, merge lanes, sloped roadways around curves for speed, the elimination of unnecessary rises and curves for improved visibility, divided highways, paved shoulders, and clearly marked lanes.

7. **Textbook questions 1 and 4 of "Check Your Understanding," p. 247**

    1. Seat belts and air bags may be the most important safety features that reduce fatalities. Refer to Figure 13.10 on page 245 of the textbook.

    4. You can use the emergency brake to stop a vehicle if the brakes suddenly failed.

Section 1 Review

1. **Textbook question 2 of "Reviewing Key Terms," p. 248**

    2. a. vii b. v c. xiii d. viii e. xiv

        f. ix g. xi h. iv i. xii j. iii

2. **Textbook question 3, 4, and 5 of "Understanding Key Ideas," p. 248**

    3. Some common injuries associated with car accidents are cuts and bruises, burns, broken bones, whiplash, internal injuries, and brain and spinal injuries.

4. Answers may vary. Important safety features of automobiles are seat belts, air bags, crumple zones, and side-impact beams.

5. Talking on a cell phone causes a delayed reaction because it distracts the driver and it keeps both hands from being on the wheel.

3. **Textbook question 6 of "Developing Skills," p. 248**

6. a. The occupant of the car hit from the rear is most likely to experience whiplash, because his head moves sharply backwards extending the neck.

   b. The other driver may receive head and facial injuries after hitting the steering wheel.

4. **Textbook questions 8 and 10 of "Problem Solving/Applying," p. 249**

8. a. The 50-kg person is likely to show more impairment because his mass is less. The alcohol would be more concentrated in his blood.

   b. The other person could show more impairment if she is tired, has a slower rate of metabolism, is taking medication, or drank on an empty stomach.

   c. Both drivers should be under the limit since 0.045 BAC should be eliminated over three hours. It is not likely that either person will have a BAC exceeding 0.125 (0.08 + 0.045) after three drinks.

10. The BAC rate is 0.146.
Alcohol leaves the body at 0.015 BAC units per hour.
The legal BAC limit is 0.08.

$$0.146\ \text{BAC} - 0.08\ \text{BAC} = 0.066\ \text{BAC}$$

The drinker's BAC is 0.066 units over the limit.

The body gets rid of 0.015 BAC units per hour.

$$\frac{0.066\ \text{BAC}}{0.015\ \text{BAC/h}} = 4.4\ \text{h}$$

It will take about 4.4 h before she can legally drive.

5. **Textbook questions 11 and 13 of "Critical Thinking," p. 249**

   11. You need to consider the medical and social costs for those who do not wear seat belts and are injured in vehicle accidents.

       - Seat belts reduce injuries and the severity of injuries.
       - In Canada, the cost of injuries are passed on to everyone.

   13. Answers will vary. Here are a few problems that could cause collisions:

       - Accidents can arise from poorly maintained brakes that keep the vehicle from stopping in time. Poorly maintained tires may result in one tire blowing, which could lead to losing control of the vehicle.
       - Poor tires and steering components could direct a vehicle into a hazard.
       - Cracked, fogged, snow- and ice-covered, or partially obscured windows could reduce the driver's vision.
       - Poor windshield wipers could also lead to obscured or poor vision.

Section 2: Lesson 1

1. **Textbook question "Reading Check," p. 252**

   Velocity is the distance travelled during a specified time interval. The two factors needed to determine velocity are distance and time.

2. You would travel 80 km.

3. **Textbook questions 1 to 4 of "What to Do?," p. 251**

   1. The impression of speed in an airplane depends on altitude. The closer the plane is to the ground, the faster the plane seems to be travelling. At very high altitudes, the plane seems to be nearly standing still.

   2. For most people, the fastest they have travelled is in a commercial airliner. Large distances covered in short periods of time tell you that you were travelling very fast.

3. Answers will vary. Your list of cues should include

   - seeing objects pass by (speed of objects passing by will vary for walking, running, cycling, and so on)
   - feeling the air rush by (on a bicycle or in a convertible car with the top down)
   - reading a speedometer
   - knowing that you have covered a given distance in a certain time (e.g., travelled from Edmonton to Calgary in 2.5 h)

4. The most common cues that tell you how fast someone or something is travelling are distance and time.

4. **Textbook questions 1, 2, and 3 of "Evaluate," p. 253**

Answers will vary. Sample answers are given.

1.

Trial	Distance	Time	Velocity
1	2 m	1.5 s	1.3 m/s
2	4 m	2.9 s	1.4 m/s
3	6 m	4.4 s	1.4 m/s

2. No, the remote-controlled car (or other object) did not travel the same velocity all the time.

3. Differences in velocity may have occurred because the car was remote controlled and battery powered. It started from a stop each time and took time to accelerate to top speed. It was also difficult to steer the car in a perfectly straight line. Also, differences in the calculated velocity may be from measurement errors in the time the car took to cover the distances in each trial.

5. **Textbook questions 1 to 4 of "Solve These," p. 255**

1. **step 1: What do you know?**

$d = 10\ \text{m}$

$t = 30\ \text{s}$

$v = ?$

step 2: What do you want to find out?

How fast are you travelling?

step 3: How do you find out?

$$v = \frac{d}{t}$$

step 4: Show the velocity as distance per time.

$$v = \frac{10\ \text{m}}{30\ \text{s}} \text{ or } 10\ \text{m}/30\ \text{s}$$

step 5: Divide the time units into the distance units.

$$v = \frac{10\ \text{m}}{30\ \text{s}}$$

$v = 0.33\ \text{m/s}$

You are travelling approximately 0.33 m/s.

2. **step 1:** $d = 2\ \text{m}$, $t = 0.5\ \text{s}$, $v = ?$

step 2: How fast is the cue ball travelling?

step 3: $v = \frac{d}{t}$

step 4: $v = \frac{2\ \text{m}}{0.5\ \text{s}}$ or $2\ \text{m}/0.5\ \text{s}$

step 5: $v = \dfrac{2\ \text{m}}{0.5\ \text{s}}$

$v = 4\ \text{m/s}$

The cue ball is travelling 4 m/s.

3. $d = 25\ \text{km}$, $t = 0.5\ \text{h}$, $v = ?$

$$v = \frac{d}{t}$$

$$v = \frac{25\ \text{km}}{0.5\ \text{h}}$$

$$v = 50\ \text{km/h}$$

You are travelling 50 km/h.

4. $d = 20\ \text{km}$, $t = 15\ \text{min}$ or $0.25\ \text{h}$, $v = ?$

$$v = \frac{d}{t}$$

$$v = \frac{20\ \text{km}}{0.25\ \text{h}}$$

$$v = 80\ \text{km/h}$$

You would have to drive 80 km/h.

6. a. $50\ \text{km/h} = \dfrac{50\ \text{km}}{1\ \text{h}}$

Convert kilometres into metres.

$$= \frac{50\ \cancel{\text{km}}}{1\ \text{h}} \times \frac{1000\ \text{m}}{1\ \cancel{\text{km}}} \times \frac{1\ \text{h}}{60\ \cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\ \text{s}}$$

Convert hours into seconds.

$$= \frac{50\ 000\ \text{m}}{3600\ \text{s}}$$

$$= 13.89\ \text{m/s}$$

b. $50\ \text{m/s} = \dfrac{50\ \text{m}}{1\ \text{s}}$

Convert metres into kilometres.

$$= \frac{50\ \cancel{\text{m}}}{1\ \cancel{\text{s}}} \times \frac{1\ \text{km}}{1000\ \cancel{\text{m}}} \times \frac{3600\ \cancel{\text{s}}}{1\ \text{h}}$$

Convert seconds into hours.

$$= \frac{180\ 000\ \text{km}}{1000\ \text{h}}$$

$$= \frac{180\ \text{km}}{1\ \text{h}} \text{ or } 180\ \text{km/h}$$

7. **Textbook questions 1 to 4 of "Check Your Understanding," p. 255**

   1. Increasing the distance increases the time if velocity stays the same.

   2. If the velocity is doubled and distance stays the same, the time would be halved.

   3. $d = 180$ km, $t = 2$ h, $v = ?$

      $$v = \frac{d}{t}$$
      $$v = \frac{180 \text{ km}}{2 \text{ h}}$$
      $$v = 90 \text{ km/h}$$

      Stacy is travelling 90 km/h.

   4. $d = 800$ m, $t = 120$ s, $v = ?$

      $$v = \frac{d}{t}$$
      $$v = \frac{800 \text{ m}}{120 \text{ s}}$$
      $$v = 6.67 \text{ m/s}$$

      Alan travels 6.67 m/s on his skateboard.

Section 2: Lesson 2

1. a. A *manipulated variable* is a variable changed by the researcher.

   b. Time is the manipulated variable in a distance/time graph.

2. a. A *responding variable* is a variable that changes as a result of changes made to the manipulated variable.

   b. Distance is the responding variable in a distance/time graph.

3. **Textbook question "Reading Check," p. 256**

   The slope or steepness of a distance/time graph gives information about the velocity. The steeper the graph (line), the greater the velocity.

4. The go-kart travels 7 m every second. Its velocity is 7 m/s.

5. The distance/time graph for the go-kart is a straight line. From this, you can tell the go-kart's velocity is constant.

6.

Time Period	Distance Travelled	Velocity
from t = 0 s to t = 1 s	*7 m (7 m – 0 m)*	*7 m/s*
from t = 1 s to t = 2 s	*10 m (17 m – 7 m)*	10 m/s
from t = 2 s to t = 3 s	13 m (30 m – 17 m)	13 m/s
from t = 3 s to t = 4 s	8 m (38 m – 30 m)	8 m/s
from t = 4 s to t = 5 s	2 m (40 m – 38 m)	2 m/s

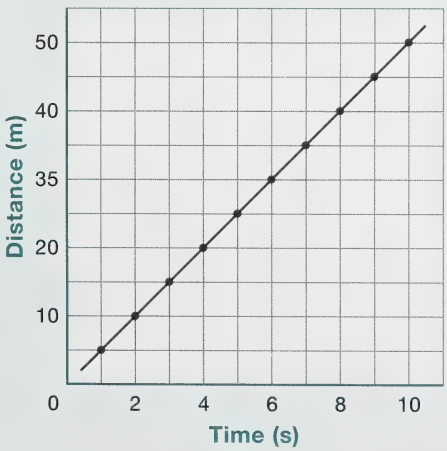
7. The dune buggy was travelling the fastest from t = 2 s to t = 3 s. The dune buggy was travelling the slowest from t = 4 s to t = 5 s. You can tell what the relative speeds are from the steepness of the graph. The steeper the graph, the faster the dune buggy was travelling.

8. **Textbook questions 1, 2, and 3 of "What to Do," p. 257**

   1. The position numbers change regularly by 5 m in each case.

   2. Because the change in distance is uniform, the data will result in a straight line.

   3. **Distance/Time Graph for Student**



9. **Textbook questions 1, 2 and 3 of "What Did You Find Out?," p. 257**

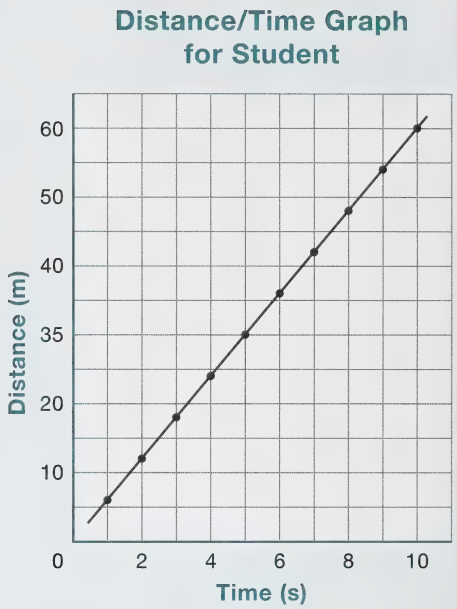
1. The runner's position changes regularly, increasing by 5 m every second.

2. The runner's velocity stays the same at 5 m/s.

3. a. If the runner's position changed by 6 m, the distance/time graph would be steeper.

b.

Time (s)	Position (m)
1	6
2	12
3	18
4	24
5	30
6	36
7	42
8	48
9	54
10	60



10. Refer to the answer to question 12 for a sample table and graph. **Note:** In question 12, the ticker tape machine was set at 30 ms.

11. a. **Textbook questions 1 and 2 of "Analyze," p. 259**

1. The ticker tape machine is started when the cart reaches level ground because the distance between the dots will be uniform from that point on. When the car is going down the ramp, it is accelerating. Actually, the ticker tape on page 259 of the textbook shows that the ticker tape machine was on from the start. The tape, however, is only labelled and measured from where the cart reached level ground (P0).

2. a. Time is the manipulated variable because you can set the timer for different time intervals.

b. The responding variable is the distance the cart travels between each pair of dots.

b. **Textbook question 3 of "Conclude and Apply," p. 259**

3. When the cart is travelling slowly, the points are close together. As the cart speeds up, the points spread out. As the cart slows down, the points get closer together. The ticker tape on page 259 of the textbook does not show the cart slowing down.

c. **Textbook question 4 of "Extend Your Skills," p. 259**

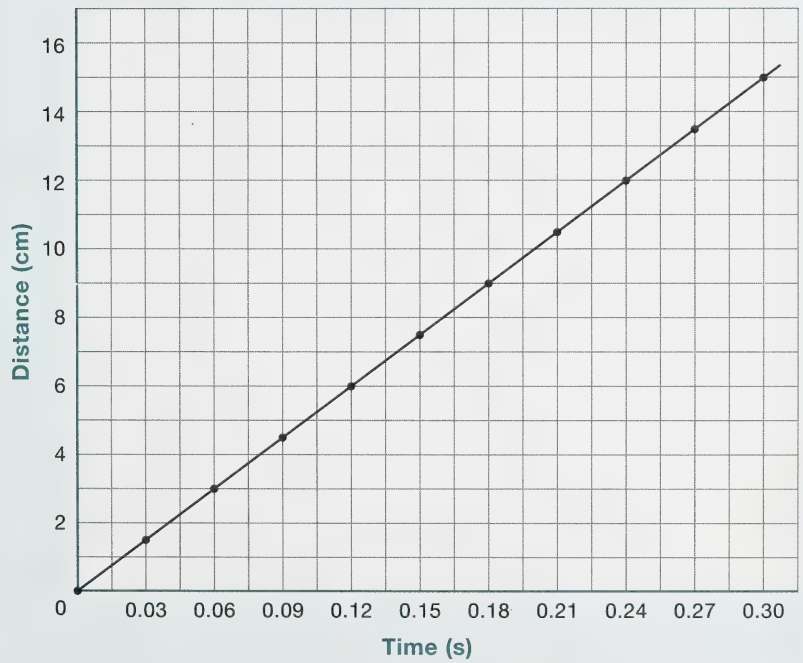
4. There are 1000 ms in one second. If the interval were set for 50 ms, there would be

$$1000 \div 50 = 20 \text{ dots/second}$$

12.

Time (s)	0	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27	0.30
Distance (cm)	0	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0

Distance/Time Graph for Dynamic Cart



13. Refer to the answers to question 11.

14. For the line between two points on a distance/time graph, the run is the time interval between the two points.

15. For the line between two points on a distance/time graph, the rise is the distance travelled between the two points.

16. $\text{slope} = \frac{\text{rise}}{\text{run}}$

17. For the line between two points on a distance/time graph, the slope represents the velocity between the two points.

18. **Textbook question 1 of "Solve These," p. 261**

    1. Two points on the graph are (0, 0) and (2, 30).

       The distance units are in metres, and the time units are in seconds.

       Calculate how far the go-kart travelled between these two points.

       $$d = 30\ \text{m} - 0\ \text{m}$$
       $$= 30\ \text{m}$$

       Calculate how long it took the go-kart to travel between the two points.

       $$t = 2\ \text{s} - 0\ \text{s}$$
       $$= 2\ \text{s}$$

       Use the formula.

       $$v = \frac{d}{t}$$
       $$v = \frac{30\ \text{m}}{2\ \text{s}}$$
       $$v = 15\ \text{m/s}$$

       The go-kart was travelling 15 m/s.

19. **Textbook questions 1 to 4 of "Check Your Understanding," p. 261**

1. The slope of a line on a distance/time graph represents velocity.

2. The horizontal line on a distance/time graph represents time.

3. On a distance/time graph, the manipulated variable is time and the responding variable is distance.

4. a. The longer line represents motion over a longer period of time. In this case, it is twice as long.

   b. The object represented by the line with the greater slope is travelling twice as fast.

Section 2: Lesson 3

1. **Textbook question "Try This!," p. 262**

You get the unit for velocity when you divide the unit for distance by the unit for time. For example, if the unit for distance is km and the unit for time is h, the unit for velocity is km/h.

You get the unit for distance when you multiply the unit for velocity by the unit for time. For example, if the unit for velocity is km/h and the unit for time is h, the unit for distance is km.

2. **Textbook questions 1 and 2 of "Solve These," p. 263**

1. $v = 56$ km/h, $t = 2.3$ h, $d = ?$

   $d = vt$

   $d = 56 \text{ km/h} \times 2.3 \text{ h}$

   $d = 128.8 \text{ km}$

   You will travel 128.8 km.

2.

	Distance	Time	Speed
Edmonton–Red Deer	148.5 km	1.35 h	110 km/h
Red Deer–Calgary	146.3 km	1.33 h	110 km/h
Calgary–Banff	159 km	1.76 h	90.3 km/h
Banff–Lake Louise	56 km	0.62 h	90.3 km/h
Lake Louise–Jasper	289 km	3.2 h	90.3 km/h
Jasper–Hinton	66 km	0.66 h	100 km/h
Hinton–Edmonton	272.8 km	2.48 h	110 km/h

The following calculations were used to complete the table.

Edmonton–Red Deer

$d = vt$

$d = 110 \text{ km/h} \times 1.35 \text{ h}$

$d = 148.5 \text{ km}$

Red Deer–Calgary

$d = vt$

$d = 110 \text{ km/h} \times 1.33 \text{ h}$

$d = 146.3 \text{ km}$

Calgary–Banff

$v = \frac{d}{t}$

$v = \frac{159 \text{ km}}{1.76 \text{ h}}$

$v = 90.3 \text{ km/h}$

Banff–Lake Louise

$v = \frac{d}{t}$

$v = \frac{56 \text{ km}}{0.62 \text{ h}}$

$v = 90.3 \text{ km/h}$

Lake Louise–Jasper

$v = \frac{d}{t}$

$v = \frac{289 \text{ km}}{3.2 \text{ h}}$

$v = 90.3 \text{ km/h}$

Jasper–Hinton

$d = vt$

$d = 110 \text{ km/h} \times 0.66 \text{ h}$

$d = 66 \text{ km}$

Hinton–Edmonton

$d = vt$

$d = 110 \text{ km/h} \times 2.48 \text{ h}$

$d = 272.8 \text{ km}$

3. $v = 100$ km/h, $t = 0.75$ h, $d = ?$

$d = vt$
$d = 100 \text{ km/h} \times 0.75 \text{ h}$
$d = 75 \text{ km}$

Tamara and Ethan have 75 km left to drive.

4. **Textbook questions 1, 2, 3, and 4.a. of "Check Your Understanding," p. 263**

1. $v = 60$ km/h, $t = 0.5$ h, $d = ?$

$d = vt$
$d = 60 \text{ km/h} \times 0.5 \text{ h}$
$d = 30 \text{ km}$

The truck travelled 30 km between 11:30 and 12:00.

2. $v = 100$ km/h, $t = 1.5$ h, $d = ?$

$d = vt$
$d = 100 \text{ km/h} \times 1.5 \text{ h}$
$d = 150 \text{ km}$

The truck travelled 150 km between 6:00 and 7:30.

3. $v = 6$ km/h, $t = 2.5$ h, $d = ?$

$d = vt$
$d = 6 \text{ km/h} \times 2.5 \text{ h}$
$d = 15 \text{ km}$

The dog trotted 15 km.

Note: The assumption is that the dog trots in a straight line behind the horse. Dogs like to go this way and that way to sniff various objects as they walk. Therefore, this is a minimum distance the dog will trot.

4. a. $\text{Total distance} = (60 \text{ km/h} \times 2 \text{ h}) + (30 \text{ km/h} \times 0.5 \text{ h}) + (100 \text{ km/h} \times 0.5 \text{ h})$
$= 120 \text{ km} + 15 \text{ km} + 50 \text{ km}$
$= 185 \text{ km}$

You travelled a total distance of 185 km.

Section 2: Lesson 4

1. Convert km/h to m/s.

$$100\ \text{km/h} = \frac{100\ \cancel{\text{km}}}{1\ \cancel{\text{h}}} \times \frac{1000\ \text{m}}{1\ \cancel{\text{km}}} \times \frac{1\ \cancel{\text{h}}}{3600\ \text{s}}$$
$$= \frac{100\,000\ \text{m}}{3600\ \text{s}}$$
$$= 27.78\ \text{m/s}$$

Calculate the distance.

$v = 27.78$ m/s, $t = 0.75$ s, and $d = ?$

$d = vt$

$d = 27.78\ \text{m/s} \times 0.75\ \text{s}$

$d = 20.8$ m

Before hitting the brakes, you would travel about 21 m.

2. **Textbook question "Reading Check," p. 264**

A 30-km/h speed limit near schools attempts to ensure that drivers will be able to stop fast enough to avoid hitting a child that darts into traffic.

3. **Textbook question "Try This!," p. 264**

Convert km/h to m/s.

$$100\ \text{km/h} = \frac{100\ \cancel{\text{km}}}{1\ \cancel{\text{h}}} \times \frac{1000\ \text{m}}{1\ \cancel{\text{km}}} \times \frac{1\ \cancel{\text{h}}}{3600\ \text{s}}$$
$$= \frac{100\,000\ \text{m}}{3600\ \text{s}}$$
$$= 27.78\ \text{m/s}$$

Calculate the distance.

$v = 27.78$ m/s, $t = 0.25$ s, and $d = ?$

$d = vt$

$d = 27.78 \text{ m/s} \times 0.25 \text{ s}$

$d = 6.9$

Your vehicle would travel about 6.9 m.

4. Stopping distance = distance travelled during reaction time + braking distance

5. **Textbook questions 1 and 2 of "Reaction Time and Stopping Distance," p. 265**

   1.

Velocity	Stopping Distance
32 km/h	18 m
48 km/h	30 m
64 km/h	46 m
80 km/h	65 m
96 km/h	86 m

   2. When the velocity doubles, the stopping distance more than doubles (about 2.5 times).

6. **Textbook question "Reading Check," p. 265**

   The recommended following distance is a two-second interval. You can check this by noting when the vehicle ahead passes a road sign. It should be at least two seconds before your vehicle passes the same sign.

7. Almost 20% of accidents are due to excessive speed.

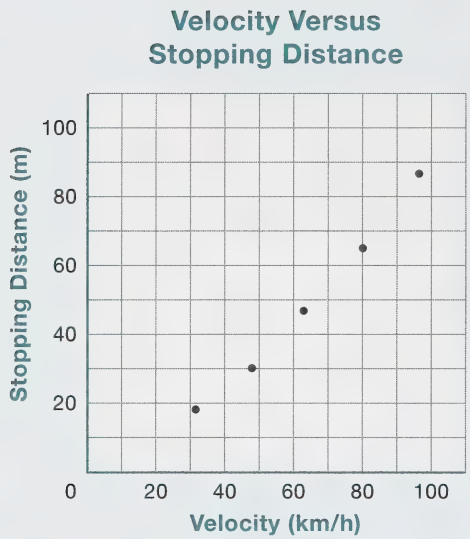
8. When speed is doubled, braking distance increases about four times. (**Note:** This is braking distance as given in the column 4 of the table on page 265 of the textbook.)

9. Four factors that increase braking distance are worn tires, gravel roads, downhill grades, and ice and snow. (Another factor is the condition of the vehicle's braking system.)

10. Reaction times normally range from 0.7 s to 1.5 s for drivers who are not impaired.

11. **Textbook questions 1 to 4 of "Check Your Understanding," p. 265**

1.



When velocity increases, stopping distances increase at a greater rate. The graph shows that the curve is almost exponential.

2. Reasons to set a yellow light to last longer include

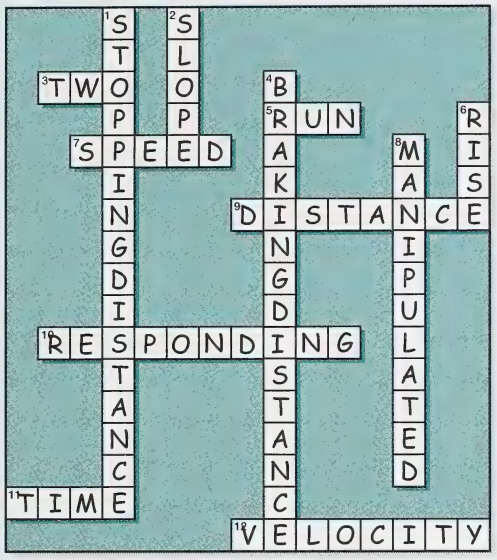
   - clearing the intersection of all vehicles before the light turns green for cross traffic
   - giving motorists more warning to stop for the red light

3. Stopping distances are greatly increased on wet or icy road surfaces. At night or in fog, drivers may not be able to see far enough ahead to be able to come to a complete stop in time. Drivers should adjust their following distances accordingly.

4. If you travel 100 km/h in a 50-km/h speed zone, you risk collisions with slower traffic and with pedestrians. The situation does not allow for prolonged stopping distances.

Section 2 Review

1.



2. a. **Textbook questions 2 and 3 of "Reviewing Key Terms," p. 266**

   2 a. Time is being manipulated.

   b. Distance is responding.

   c. The slope represents the ball's velocity.

   d. Since the slope represents velocity, the unit you would use is m/s.

   3. Yes, a steep line on a distance/time graph does show a faster velocity than a line that is not as steep.

   b. **Textbook questions 4 and 5 of "Understanding Key Ideas," p. 266**

   4. $d = vt$

   5. Two points on the graph are (2, 1) and (4, 2).

      Calculate the distance between the two points.

$$d = 2\text{ m} - 1\text{ m}$$
$$= 1\text{ m}$$

Calculate the time between the two points.

$$t = 4\ \text{s} - 2\ \text{s}$$
$$= 2\ \text{s}$$

Use the formula.

$$v = \frac{d}{t}$$
$$v = \frac{1\ \text{m}}{2\ \text{s}}$$
$$v = 0.5\ \text{m/s}$$

c. **Textbook question 6 of "Developing Skills," p. 267**

6. a. $d = 400\ \text{km}$, $t = 5\ \text{h}$, $v = ?$

$$v = \frac{d}{t}$$
$$v = \frac{400\ \text{km}}{5\ \text{h}}$$
$$v = 80\ \text{km/h}$$

You will have to drive 80 km/h.

b. $d = 400\ \text{km}$, $t = 6\ \text{h}$, $v = ?$

$$v = \frac{d}{t}$$
$$v = \frac{400\ \text{km}}{6\ \text{h}}$$
$$v = 66.67\ \text{km/h}$$

You would want to maintain 67.7 km/h.

d. **Textbook questions 9, 10, and 11 of "Problem Solving/Applying," p. 267**

9. $v = 90\ \text{km/h}$, $t = 3 \times 12\ \text{h}$, $d = ?$
$= 36\ \text{h}$

$$d = vt$$
$$d = 90\ \text{km/h} \times 36\ \text{h}$$
$$d = 3240\ \text{km}$$

The trucker can travel 3240 km.

10. $d = 0.050\ \text{km}, t = 0.000\ 42\ \text{h}, v = ?$

$$v = \frac{d}{t}$$

$$v = \frac{0.050\ \text{km}}{0.000\ 42\ \text{h}}$$

$$v = 119.05\ \text{km/h}$$

The car is going about 119 km/h.

11. $d = 250\ \text{km}, t = 2\ \text{h}, v = ?$

$$v = \frac{d}{t}$$

$$v = \frac{250\ \text{km}}{2\ \text{h}}$$

$$v = 125\ \text{km/h}$$

Your friend's average velocity is 125 km/h.

$d = 250\ \text{km}, t = 3\ \text{h}, v = ?$

$$v = \frac{d}{t}$$

$$v = \frac{250\ \text{km}}{3\ \text{h}}$$

$$v = 83.33\ \text{km/h}$$

Your average velocity is about 83.3 km/h.

e. **Textbook question 12 of "Critical Thinking," p. 267**

12. Answers will vary. Reasons for those supporting reduced highway speeds include the following:

- Lower speeds reduce the severity of accidents.
- Lower speeds allow drivers to react in time to avoid accidents.
- Lower speeds save fuel and help protect the environment.

Section 3: Lesson 1

1. Momentum is a measure of an object's motion and how likely it is to remain in motion.

2. Force is a push or pull on an object.

3. **Textbook question "Reading Check," p. 270**

   The factors that determine the force required to move an object are how long you apply the force, the mass of the object, and how fast you want the object to go.

4. The more momentum an object has, the more force and/or time are needed to stop it.

5.

Cart	Time from Bottom of Ramp to Box	Distance from Bottom of Ramp to Box	Velocity of Cart	Distance Box Travelled
empty	0.50 s	1 m	2 m/s	50 cm
with 100-g mass	0.50 s	1 m	2 m/s	60 cm
with 200-g mass	0.50 s	1 m	2 m/s	70 cm
empty on ramp raised to double original height	0.25 s	1 m	4 m/s	100 cm
with 100 g on ramp raised to double original height	0.25 s	1 m	4 m/s	120 cm
with 200 g on ramp raised to double original height	0.25 s	1 m	4 m/s	140 cm

6. When only the mass of the object increased, the object's momentum increased.

7. When only the velocity of the object increased, the object's momentum increased.

8. Refer to the completed table in the answer to question 5.

9. Refer to the answers to questions 6 and 7.

10. **Textbook question "Reading Check," p. 271**

momentum (kg•m/s) = mass (kg) × velocity (m/s)

11. **Textbook question "Solve These," p. 271**

Object	Mass	Velocity	Momentum
adult female fly	0.000 012 kg	5 km/h (1.4 m/s)	0.000 017 kg•m/s
adult female human	70 kg	5 km/h (1.4 m/s)	98 kg•m/s
adult female on 5-kg bicycle	75 kg	30 km/h (8.3 m/s)	622.5 kg•m/s
adult female on motorcycle	250 kg	50 km/h (13.9 m/s)	3475 kg•m/s
compact car	750 kg	50 km/h (13.9 m/s)	10 425 kg•m/s
compact car	750 kg	100 km/h (27.8 m/s)	20 850 kg•m/s
transport truck	2500 kg	50 km/h (13.9 m/s)	34 750 kg•m/s
transport truck	2500 kg	100 km/h (27.8 m/s)	69 500 kg•m/s

12. The best way to reduce momentum in a vehicle is by braking.

13. Friction is the force that two objects exert on each other when they rub or press against each other.

14. Braking uses the friction between brake pads and drums (or rotors) to reduce the momentum of the vehicle. The friction between the brake pads and drums (or rotors) converts the kinetic energy of the car into heat energy. The friction between the tires and the road provide stability but does not dissipate much energy.

15. **Textbook question "Reading Check," p. 272**

Icy roads reduce braking ability because the friction between tires and the road is reduced. The wheels will lock up, converting no kinetic energy of the vehicle into heat energy by the rubbing of the brake pads and the drums (or rotors).

16. Your completed table should be similar to the following.

Cart	Total Mass	Distance Cart Travelled
empty cart	500 g	4.0 m
with 100-g mass	600 g	4.8 m
with 500-g mass	1000 g	8.0 m

17. **Textbook questions 1, 2 and 3 of "What Did You Discover?," p. 273**

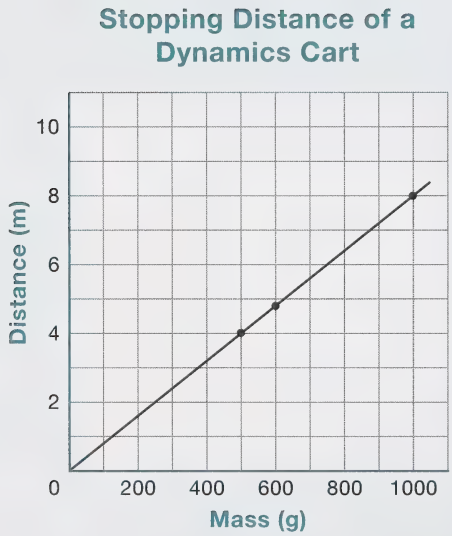
1. a. An increase in mass made the cart go farther before stopping on its own.

   b. For a given velocity, the greater the mass of an object, the greater its momentum.

2. a. For a given velocity, the greater the mass of a vehicle, the greater its stopping distance.

   b. It takes so long for a freight train to stop because its mass is so large.

3.



There is a direct relationship between mass and stopping distance. According to the graph, doubling the mass doubles the stopping distance.

18. **Textbook questions 1, 2, and 3 of "Check Your Understanding," p. 273**

    1. It might be harder to stop a vehicle travelling at 30 km/h on icy surfaces or on loose gravel than one travelling at 60 km/h on a dry, paved road.

    2. A snail crawling along a leaf has a very low momentum because its speed is very low and its mass is small. A loaded transport plane travelling 700 km/h has a very high momentum because it has a large mass and is travelling at a high speed.

    3. a. Momentum doubles when velocity doubles.

       b. Momentum doubles when mass doubles.

       c. Momentum increases four times when both velocity and mass double.

Section 3: Lesson 2

1. *Impulse* is the combination of force and the time it acts.

2. Impulse applied to an object equals the object's change in momentum.

3. impulse = force × time

4. The unit for impulse is kg•m/s. The units for impulse and for momentum are the same. One common unit is kg•m/s.

5. **Textbook questions 1 to 4 of "Solve These," p. 275**

    1. force = 1000 $kg \cdot m/s^2$, time = 1 s, impulse = ?

       impulse = force × time

       $= 1000\ kg \cdot m/s^2 \times 1\ s$

       $= 1000\ kg \cdot m/s$

       The impulse of the collision is 1000 kg•m/s.

2. force = 1000 $kg \cdot m/s^2$, time = 2 s, impulse = ?

   impulse = force × time
   $= 1000\ kg \cdot m/s^2 \times 2\ s$
   $= 2000\ kg \cdot m/s$

   The impulse of the collision would be 2000 kg•m/s.

3. force = 400 N or 400 $kg \cdot m/s^2$, time = 0.5 s, impulse = ?

   impulse = force × time
   $= 400\ kg \cdot m/s^2 \times 0.5\ s$
   $= 200\ kg \cdot m/s$

   Recall that 1 N = 1 $kg \cdot m/s^2$

   The impulse of the slide is 200 kg•m/s.

4. force = 400 $kg \cdot m/s^2$, time = 2 s, impulse = ?

   impulse = force × time
   $= 400\ kg \cdot m/s^2 \times 2\ s$
   $= 800\ kg \cdot m/s$

   The impulse of the slide would be 800 kg•m/s.

6. **Textbook question "Reading Check," p. 275**

   Three different ways to change momentum include changing velocity, changing mass, and adding an impulse.

7. You can create a larger impulse by adding a greater force or by applying the same force over a longer period of time.

8. **Textbook questions 1 and 2 of "What Did You Find Out?," p. 276**

   1. When the cart is given an impulse from behind, the plastic figurine is thrown backward. When an impulse immediately stops the cart from the front, the momentum of the plastic figurine continues forward, thus throwing the figurine forward.

   2. Pull the tablecloth quickly towards you. The tendency of the dishes to stay in place should, with luck, keep them in place. **Note:** Do not try this with breakable dishes.

9. **Textbook questions 1 to 5 of "Check Your Understanding," p. 276**

1. You can increase the time interval you use to stop for a red light by anticipating when the light will turn yellow and slowing down as you get closer to the intersection.

2. Increasing your stopping time keeps you from continuing forward while the vehicle is slowing down. This keeps you from hitting the dashboard or windshield, thus decreasing the risk of injury.

3. For a given impulse, because impulse = force × time, you can use a large force applied for over a short time to stop the car or you can use a smaller force applied for a proportionately longer period of time. Half the force requires twice the time to produce the same impulse.

   For example, given an impulse of 1000 kg•m/s,

   $$1000\ \text{kg•m/s} = 500\ \text{kg•m/s}^2 \times 2\ \text{s} \quad \text{and} \quad 1000\ \text{kg•m/s} = 250\ \text{kg•m/s}^2 \times 4\ \text{s}$$

   There are an infinite number of combinations of force and time that will create an impulse of 1000 kg•m/s.

4. A speeding car, because of its mass and velocity, has a high momentum—a tendency to remain in motion in a straight line and at a constant speed. When the brakes are applied, a frictional force between the brake pads and the drums (or rotors) slows the car. Remember, a force is a push or pull. The friction forces are applied for a length of time. A force applied for a length of time is the impulse that slows the vehicle.

5. force = 50 000 kg•m/s^2, time = 5 s, impulse = ?

   impulse = force × time

   $= 50\ 000\ \text{kg•m/s}^2 \times 5\ \text{s}$

   $= 250\ 000\ \text{kg•m/s}$

   The impulse is now 250 000 kg•m/s.

Section 3: Lesson 3

1. Impulse, change in velocity, and change in momentum are the same.

2. **Textbook question "Reading Check," p. 277**

   The forces experienced in a collision are greater if the time period is shorter.

3. **Textbook questions 1, 2, and 3 of "Solve These," p. 278**

1. a. mass = 1200 kg

$$\text{force} = \frac{\text{mass} \times \text{change in velocity}}{\text{time}}$$

$$\text{change in velocity} = \text{velocity}_2 - \text{velocity}_1$$
$$= 0 \text{ m/s} - 28 \text{ m/s}$$
$$= -28 \text{ m/s}$$

$$= \frac{1200 \text{ kg} \times (-28 \text{ m/s})}{1 \text{ s}}$$
$$= -33\,600 \text{ kg} \cdot \text{m/s}^2$$

time = 1 s

The force involved was $-33\,600$ kg•m/s^2.

b. $\dfrac{-33\,600 \text{ kg} \cdot \text{m/s}^2}{-1344 \text{ kg} \cdot \text{m/s}^2} = 25$

This force is 25 times larger in the sample problem.

2. mass = 2000 kg

$$\text{force} = \frac{\text{mass} \times \text{change in velocity}}{\text{time}}$$

$$\text{change in velocity} = \text{velocity}_2 - \text{velocity}_1$$
$$= 8 \text{ m/s} - 28 \text{ m/s}$$
$$= -20 \text{ m/s}$$

$$= \frac{2000 \text{ kg} \times (-20 \text{ m/s})}{2 \text{ s}}$$
$$= -20\,000 \text{ kg} \cdot \text{m/s}^2$$

time = 2 s

The vehicle experiences a force of $-20\,000$ kg•m/s^2.

3. a. mass = 1500 kg

$$\text{force} = \frac{\text{mass} \times \text{change in velocity}}{\text{time}}$$

$$\text{change in velocity} = \text{velocity}_2 - \text{velocity}_1$$
$$= 0 \text{ m/s} - 28 \text{ m/s}$$
$$= -28 \text{ m/s}$$

$$= \frac{1500 \text{ kg} \times (-28 \text{ m/s})}{0.5 \text{ s}}$$
$$= -84\,000 \text{ kg} \cdot \text{m/s}^2$$

time = 0.5 s

The vehicle experiences a force of $-84\,000$ kg•m/s^2.

b. $$\frac{-84\ 000\ \text{kg}\cdot\text{m/s}^2}{-20\ 000\ \text{kg}\cdot\text{m/s}^2} = 4.2$$

This force is 4.2 times larger than the force in question 2.

4. The driver of Car B (hitting the brick wall) experiences a greater force. The driver of Car B experiences a force that is 25 times greater than the force experienced by the driver of Car A (as calculated in question 1.b. of "Solve These" on page 278 of the textbook).

5. Your table should be similar to the following.

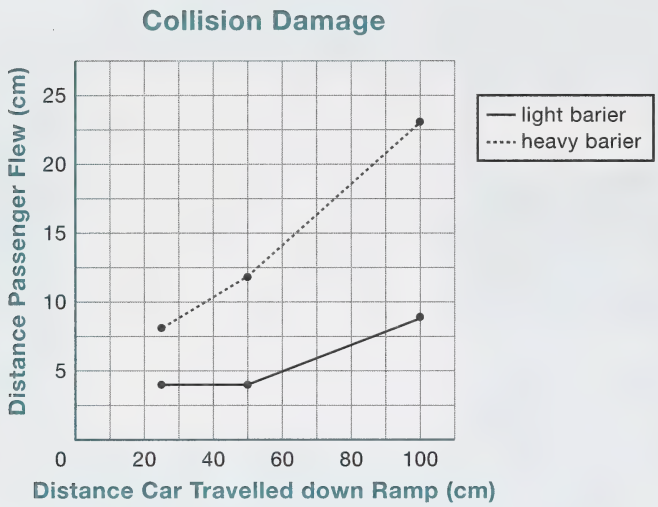
Starting Point: Distance up Ramp	Light Barrier		Heavy Barrier	
	Distance from Barrier to Landing Point	Damage to Passenger	Distance from Barrier to Landing Point	Damage to Passenger
25 cm	4 cm	• passenger continued forward • no visible damage • barrier moved 3–4 cm	8 cm	• passenger continued forward • no visible damage • barrier moved very little
50 cm	4 cm	• passenger continued forward • no visible damage • barrier moved 9 cm	12 cm	• passenger continued forward • slight damage to head and body • barrier moved very little
100 cm	9 cm	• passenger continued forward • slight damage to head and body • barrier moved 18 cm	23 cm	• passenger continued forward • significant damage to head and body • barrier moved very little

6. **Textbook questions 1, 2, and 3 "Analyze," p. 279**

   1. The velocity and momentum of the car drops to zero more quickly when it hits the heavy barrier than when it hits the light barrier.

   2. a. The force of the collision was much greater when it hit the heavy barrier than when it hit the light barrier.

      b. The light barrier moved with the toy car and slowed it down gradually. The heavy barrier stopped the car suddenly.

   3. 

7. **Textbook questions 1, 2, and 3 of "Check Your Understanding," p. 280**

   1. The changes in momentum between the two situations are the same because the change in velocity is the same in both cases.

   2. In a collision, the greater the initial velocity, the greater the impulse required to stop the car. The greater the impulse, the greater the forces experienced by the vehicle and passenger in the collision.

3. If you lengthen the time it takes to change in velocity, the force will decrease.

   Consider a 1000-kg car stopping from 30 m/s in 1 s and in 10 s.

   Determine the force in 1 s.

$$\text{force} = \frac{\text{mass} \times \text{change in velocity}}{\text{time}}$$
$$= \frac{1000\ \text{kg} \times (-30\ \text{m/s})}{1\ \text{s}}$$
$$= -30\,000\ \text{kg} \cdot \text{m/s}^2$$

   Determine the force in 10 s.

$$\text{force} = \frac{\text{mass} \times \text{change in velocity}}{\text{time}}$$
$$= \frac{1000\ \text{kg} \times (-30\ \text{m/s})}{10\ \text{s}}$$
$$= -3000\ \text{kg} \cdot \text{m/s}^2$$

   Over 1 s, the force is ten times greater than over 10 s.

Section 3: Lesson 4

1. When momentum is lost, the energy of movement changes to other forms, such as heat and the energy of crumpling metal and shattering glass.

2. a. The car that rear-ends the other car experiences a negative force because it slows down.

   b. The car that is rear-ended experiences a positive force because it speeds up.

3. The Law of Conservation of Momentum tells you that the total momentum immediately after a collision is the same as the total momentum immediately before the collision.

4. Calculate the total momentum before the accident.

$$\begin{aligned}\text{momentum of truck} &= \text{mass} \times \text{velocity} \\ &= 2000\ \text{kg} \times 5\ \text{km/h} \\ &= 10\ 000\ \text{kg•km/h}\end{aligned}$$

$$\begin{aligned}\text{momentum of your car} &= \text{mass} \times \text{velocity} \\ &= 1000\ \text{kg} \times 0\ \text{km/h} \\ &= 0\ \text{kg•km/h}\end{aligned}$$

$$\begin{aligned}\text{total momentum} &= 10\ 000\ \text{kg•km/h} + 0\ \text{kg•km/h} \\ &= 10\ 000\ \text{kg•km/h}\end{aligned}$$

By the Law of Conservation of Momentum, the total momentum immediately after the collision is also 10 000 kg•km/h.

The combined mass of the vehicles is 3000 kg. Treat this mass as the mass of a single object travelling at velocity *v*.

$$\text{velocity} = \frac{\text{total momentum}}{\text{mass}}$$

$$v = \frac{10\ 000\ \text{kg•km/h}}{3000\ \text{kg}}$$

$$v = 3.3\ \text{km/h}$$

After the collision, the two vehicles will travel approximately 3.3. km/h.

5. Car A has a positive momentum because it is travelling to the right. Car B has a negative momentum because it is travelling to the left.

6. **Textbook question "Reading Check," p. 281**

In Figure 15.9 the two cars had equal, but opposite, momentums. The two momentums cancel each other out. This verifies the Law of Conservation of Momentum because the two vehicles have zero velocity and zero momentum after the collision.

7. **Textbook questions "Try This!," p. 281**

   If two cars have the same momentum, the cars will stop immediately in a head-on collision.

   If Car A has a greater momentum, the cars will travel in the direction Car A was travelling immediately after a head-on collision.

   If Car B has a greater momentum, the cars will travel in the direction Car B was travelling immediately after a head-on collision.

8. Before the collision, M1 travelled to the right and M2 is stationary. After the collision, the two masses travelled together at a velocity of 2.5 units to the right.

9. Before the collision, M1 travelled to the right and M2 travelled to the right at a slower speed. After the collision, the two masses travelled together at a velocity of 3.5 units to the right.

10. Before the collision, M1 travelled to the right and M2 travelled to the left at the same speed. After the collision, the two masses were stationary.

11. Before the collision, M1 travelled to the right and M2 travelled to the left at the same speed. After the collision, the two masses travelled together at a velocity of 3 units to the left.

12. **Textbook questions 1 to 4 of "Analyze," p. 282**

    1. In Collision 1, Car A slows down and Car B speeds up.
       In Collision 2, Car C and Car D stop.
       In Collision 3, Car E and Truck F travel to the left.

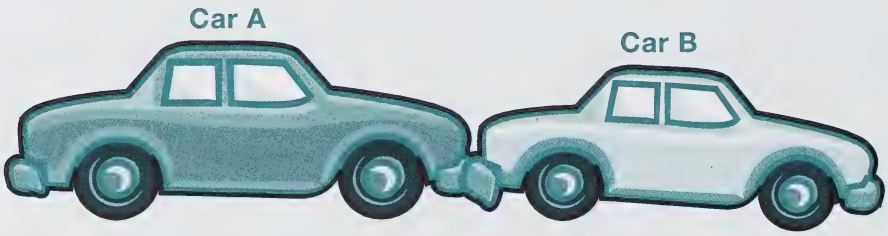
    2. In Collision 1, Car A loses momentum and Car B gains momentum; but the total momentum is conserved.

       In Collision 2, Car C and Car D lose all momentum; but the total momentum is conserved since $(+\text{X momentum}) + (-\text{X momentum}) = 0$.

       In Collision 3, Car E changes direction and gains momentum in the negative direction. Truck F loses momentum; but the total momentum, (+X momentum) + (–Y momentum), is conserved. The momentum the truck loses goes into changing the direction of the car.

3. In each collision, the drivers continue to move with the same velocities and in the same direction as before the collision. In each collision, the driver movement is opposite to the change in momentum of the vehicle.

4.

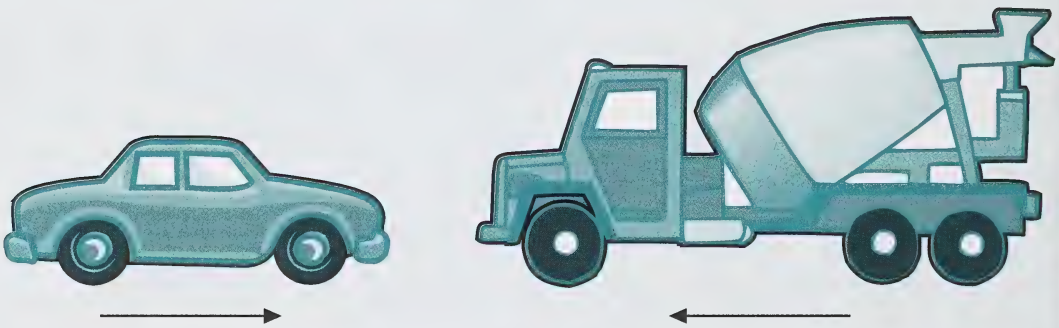


a. Making Car B half the size of Car A will make the momentum of Car B half that of Car A.

b. As a result, Car A will not slow down as much after the collision, and Car B will be driven to the right at a faster speed.

13. **Textbook question 1 of "Solve This," p. 283**

1.



2000 kg
100 km/h
+200 000 kg•km/h

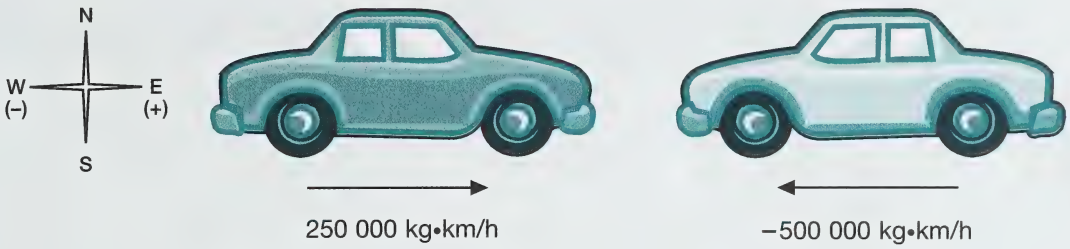
10 000 kg
100 km/h
−1 000 000 kg•km/h

$$\text{total momentum} = +200\,000\ \text{kg•km/h} + (-1\,000\,000\ \text{kg•km/h})$$
$$= -800\,000\ \text{kg•km/h}$$

After the collision, the total momentum is −800 000 kg•km/h. The negative sign means the two vehicles will travel to the left after the collision.

14. **Textbook question 2 of "Check Your Understanding," p. 283**

2.



$$\text{total momentum} = 250\,000\ \text{kg•km/h} + (-500\,000\ \text{kg•km/h})$$
$$= -250\,000\ \text{kg•km/h}$$

After the collision, the vehicles will travel west. **Note:** Your diagram could include the two cars stuck together and moving west with a momentum of –250 000 kg•km/h.

Section 3 Review

1. **Textbook question 1, 2, and 3 of "Reviewing Key Terms," p. 284**

1. a. A force is a push or a pull an object experiences.

$$\text{force} = \frac{\text{mass} \times \text{change in velocity}}{\text{time}}$$

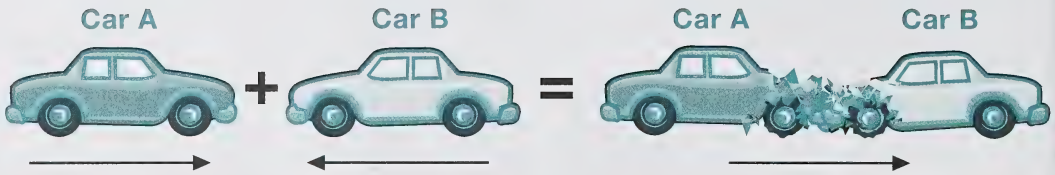
b. Impulse is a force acting over time.

$$\text{impulse} = \text{force} \times \text{time}$$

c. Momentum is a measure of an object's motion and how likely it is that the object will remain in motion.

$$\text{momentum} = \text{mass} \times \text{velocity}$$

2.



$$1000\ \text{kg} \times 100\ \text{km/h} + 1000\ \text{kg} \times (-60\ \text{km/h})$$
$$= 100\,000\ \text{kg•km/h} + (-60\,000\ \text{kg•km/h})$$
$$= 40\,000\ \text{kg•km/h}$$

$$2000\ \text{kg} \times 20\ \text{km/h}$$
$$= 40\,000\ \text{kg•km/h}$$

Total Momentum Before Collision = Total Momentum After Collision

3. Two cars are travelling along a straight road towards each other. The momentum of Car A is a product of its mass and its velocity. The momentum of Car B is a product of its mass and its velocity.

total momentum = momentum of Car A + momentum of Car B

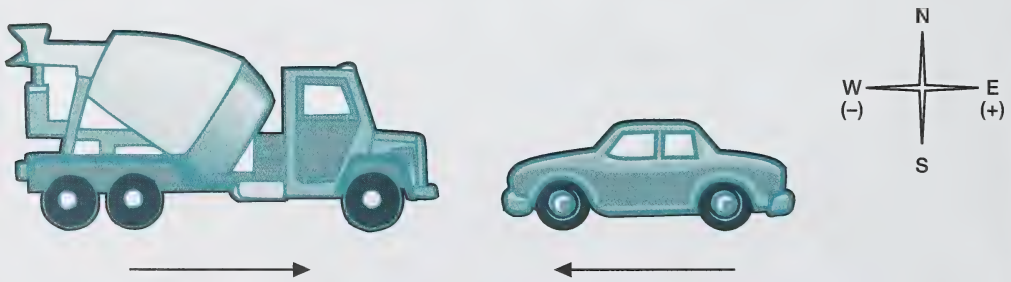
2. **Textbook questions 4 and 6 of "Understanding Key Ideas," p. 284**

4. Larger objects take longer to stop than smaller objects at the same speed because larger objects have greater momentum. They require a longer time or a greater force to stop this greater momentum.

6. Brakes work to stop your car through friction between brake shoes (or brake pads) and the brake drums (or rotors) and friction between the vehicle's tires and the road. It is the friction between the brake shoes or pads and the drums (or rotors) that converts the kinetic energy of the car into heat energy as it slows down.

3. **Textbook questions 10 and 11 of "Problem Solving/Applying," p. 285**

10.



a. momentum = mass × velocity

$= 18\ 000\ \text{kg} \times 80\ \text{km/h}$

$= 1\ 440\ 000\ \text{kg}\cdot\text{km/h}$

The momentum of the truck is 1 440 000 kg•km/h.

b. momentum = mass × velocity

$= 1000\ \text{kg} \times (-140\ \text{km/h})$

$= -140\ 000\ \text{kg}\cdot\text{km/h}$

The momentum of the car is −140 000 kg•km/h.

c. final momentum = momentum of truck + momentum of car

$= 1\ 440\ 000\ \text{kg}\cdot\text{km/h} + (-140\ 000\ \text{kg}\cdot\text{km/h})$

$= 1\ 300\ 000\ \text{kg}\cdot\text{km/h}$

d. The vehicles will move eastward because the truck's momentum is greater.
Note: Your diagram could include the truck and car stuck together and moving east with a total momentum of 1 300 000 kg•km/h.

11. impulse = force × time

$= 6000\ \text{kg}\cdot\text{m/s}^2 \times 10\ \text{s}$

$= 60\ 000\ \text{kg}\cdot\text{m/s}$

The truck experiences an impulse of 60 000 kg•m/s.

4. **Textbook question 13 of "Critical Thinking," p. 285**

13. People shake a ketchup bottle to give the contents momentum. Impulses change the bottle's momentum and direction; but the ketchup itself tends to retain its original momentum towards the neck of the bottle and forces its way out. It is the starting of the bottle and contents and then the sudden stopping of the bottle that forces the contents out.

Section 4: Lesson 1

1. **Textbook question 2 of "What to Do," p. 287**

   2. a. Some of the features related to safety present in both models include the speedometer, gauges, horn, brakes, windshield, rear- and side-view mirrors, headlights, and bumpers.

      b. Features that have changed in the 2000 model over the 1959 model include a larger windshield; larger rear- and side-view mirrors that are adjustable from inside the car, daytime running lights; three-point seat belts; a softer, more impact-absorbing dashboard; larger, more visible signal lights; and bumper materials that are more impact absorbing.

      c. Older safety features no longer present are the lap belt and the heavy steel body design.

      d. New safety features include air bags, bucket seats, headrests, crumple zones, side-impact beams, roll cages, and improved tires.

2. The safety engineer creates new safety features and improves existing safety features.

3. The idea behind most safety features is that the forces experienced in a collision will be smaller if the change in momentum can be extended over a longer period of time.

4. Crash test dummies provide information as to what would happen to real people in a collision.

5. Crumple zones include the hood, doors, fenders, and the trunk. The frames within these areas are designed to crumple when hit. Crumple zones slow down the changes in momentum during a collision and reduce the forces experienced by the occupants.

6. a. Restraining features include seat belts, air bags, head rests, and child seats.

   b. Operational features include headlights, rear- and side-view mirrors, tail lights, signal lights, and brakes.

   c. Structural features include crumple zones, heavy frame, roll cage, and side-impact beams.

7. Older cars did not absorb much of the impact in a collision because they had heavy metal bodies that did not crush easily to absorb the energy of the collision. The older cars also had heavy steel frames that went the length of the car and did not crush easily.

8. Modern designs use lighter, more bendable materials to absorb energy in a collision.

9. Parts in modern vehicles made of rigid materials include the protective cage around the occupants, side-impact beams to protect occupants from side collisions, and a beam in the dash to prevent the engine from coming into the front passenger compartment.

10. Road safety features reduce the force of a collision by reducing the impulse (increasing the time during which the collision occurs).

11. Three road safety features are

    - crash cushions filled with sand or water that burst on impact
    - guardrails that bend to absorb the force of a collision
    - light poles designed to snap off when hit

12. **Textbook questions 1 and 4 of "Check Your Understanding," p. 291**

    1. Cars with crumple zones absorb energy in a collision. This slows the change in momentum in a collision.

    4. To ensure that safety features operate properly to avoid or lessen the effects of an accident, they should be maintained on a regular basis. These include brakes, steering components, horn, gauges, and tires.

Section 4: Lesson 2

1. **Textbook question "Reading Check," p. 292**

   The original lap belt held a person across the pelvis. With only the lap belt, the upper body of the occupant still moved forward in the event of an accident. The shoulder harness runs diagonally across the chest and restrains the upper body. The shoulder harness provides better protection.

2. Manufacturers changed the design of seat belts to offer better protection, to respond to consumer advocates, and to comply with government regulations.

3. The benefit of a 4-point seat belt is that the force of restraint is spread out over the entire chest. This reduces stress on the ribs, heart, and lungs.

4. The material of a seat belt is made of thousands of thin strands of polyester or nylon. The fibres are arranged to allow the belt to stretch 10–15%.

5. **Textbook question "Reading Check," p. 293**

   The webbing is designed to stretch to allow the wearer to stop more gradually and experience less force.

6. The retractor unit uses a spring-loaded spool to keep the belt snug across the pelvis and chest of the wearer. In the event of an accident, a second mechanism—consisting of a pendulum, rod, and ratchet—locks the spool and keeps the belt in place. In an accident, momentum flips up the pendulum and an attached rod blocks the ratchet from rotating.

7. The straps cross your pelvis and runs snugly across your chest.

8. **Textbook question "Reading Check," p. 295**

   Dangerous use of seat belts includes running the shoulder strap behind your back, across the neck, or under the arm. Running the shoulder strap behind your back would not restrain your upper body in an accident. Running the shoulder strap across your neck could lead to some sort of neck trauma due to the stress inflicted by the belt in an accident; this could possibly result in death. Wearing the shoulder harness under your arm can cause the belt to put severe stress on your heart, lungs, and lower ribs. Also, wearing the straps too loosely could permit you to leave the harness in the event of an accident.

9. **Textbook questions 1 to 5 of "Analyze," p. 296**

   1. As a person ages, from infancy to adulthood, the ratio of head size to body size decreases.

   2. Relatively large heads in infants means the forces of an accident may propel their heads more violently. This increases the changes of serious injury or death.

   3. Infant and child seats are designed to support the head and neck. Some infant seats are designed to be adjustable as the infant grows. (The straps can be inserted in different positions.)

   4. a. The fluid in a mother's body cushions blows, thus protecting the fetus.

      b. Fluid to cushion blows is used in air-bag technology.

   5. In an infant seat, the child faces backwards so that the force of a front-end crash would be absorbed by the back of the child and the back of the seat.

10. Approximately 10 000 children are injured each year because they are not properly restrained.

11. Children should be seated in the back seat to prevent them from striking the dashboard, being cut by flying glass, or being injured by the deployment of air bags.

12. Infant car seats should face toward the back of the vehicle so that the force of a front-end crash would be absorbed by the entire back of the child.

13. Children should be moved to a child seat when they weigh more than 9 kg.

14. Older children who are not tall enough for the shoulder strap to cross their chest should use a booster seat so that the shoulder strap fits properly across the child's chest.

15. **Textbook questions 2, 4.a., and 5 of "Check Your Understanding," p. 297**

    2. The pendulum in a seat-belt mechanism swings forward in an accident because its momentum tends to maintain its motion.

    4. a. A baby should never be carried in a passenger's lap because even the strongest person could not hold onto a child as forces of an accident rip the child from his or her arms. The child would then become a projectile and be seriously injured or killed. Also, the person holding the child could move forward crushing the child against the dashboard.

    5. Restraints designed to protect race and rally drivers led to the development and introduction of the 4-point safety belt for passenger vehicles. Test dummies would have been used to show the benefits of the 4-point seat belt over the 3-point seat belt.

Section 4: Lesson 3

1. Air bags, like parachutes, slow the velocity and momentum of those they are designed to protect.

2. Air bags inflate in 30 milliseconds (ms).

3. **Textbook question "Reading Check," p. 298**

   In a collision, sensors send an electric signal to ignite a canister of sodium azide $\left(NaN_{3(s)}\right)$. Approximately 67 L of nitrogen gas is produced that inflates the air bag.

4. Air bags have been improved by having them inflate slower and not as much. Air bags are located in the steering column and in the dashboard on the passenger side.

5. Because of the force with which air bags inflate, small children are at risk of injury or death in the front seat of a vehicle involved in a collision.

6. **Textbook questions 1 to 4 of "Analyze," p. 299**

    1. Dropping the egg onto the balloon best simulates what happens to a person in a serious accident. In an accident, the person flies forward into the air bag at the speed at which the vehicle was travelling.

    2. The balloon that was filled to the point where it was firm but not hard yielded the best results.

    3. Did your eggs break when they were dropped on the under-inflated balloon and on the over-inflated balloon? The eggs likely rebounded and then broke when they were dropped on the over-inflated balloon.

    4. You should use a seat belt in conjunction with an air bag to keep you from rebounding dangerously off the air bag. Without a seat belt, your body would bounce off the air bag like the egg that was dropped.

7. **Textbook question 1 of "Evaluate," p. 299**

    1. Answers will vary. You may have considered surrounding the entire passenger compartment with air bags that would deploy in an accident. You may also have considered electronic sensing equipment that would prevent collisions or reduce the chance of head-on collisions. Such equipment would have to take over control of the vehicle when it senses that a collision is inevitable. You may have considered seats that could move backwards at a controlled rate in the event of a rear-end collision. Whatever the safety feature, it should reduce the force the passenger feels by lengthening the time the driver or passenger has to slow down during the collision.

8. Some of the features of third generation air bags include seat sensors that detect the mass of the occupant and adjust the force of the air bag, and switches that can be used to deactivate the air bag if a child is in the front seat.

9. **Textbook questions "Reading Check," p. 301**

    First generation air bags were designed for adult males. They often deploy with too much force. Second generation bags deploy at a safer speed and with lesser force.

10. About 30 times as many people have been saved by air bags than have been killed by air bags.

11. **Textbook questions 1 to 5 of "Check Your Understanding," p. 301**

1. An air bag can cushion the force of a collision, keep your head from moving too far forward, prevent you from striking the dashboard or windshield, and limit lateral movement.

2. You should not depend on the air bag alone because, in an accident, it may not deploy or it may burst. Also, you may bounce off the bag when it does deploy and be injured from striking other parts of the vehicle. You may also be thrown above or below the bag.

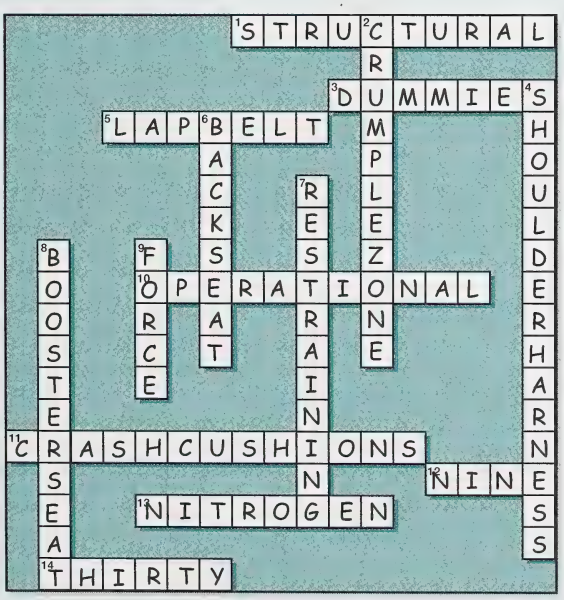
3. Air bags can injure children by the forces involved in inflating the bag. Also, air bags are positioned for adult-sized passengers.

4. First generation air bags were designed for adult males and often deployed with too much force.

5. The need for protection for children and the success of the protection provided by second generation air bags has led to the development of third generation air bags. Crash test dummies of varying heights and masses would have been used to design third generation air bags to be effective and safe for a wide range of passenger sizes and weights.

Section 4 Review

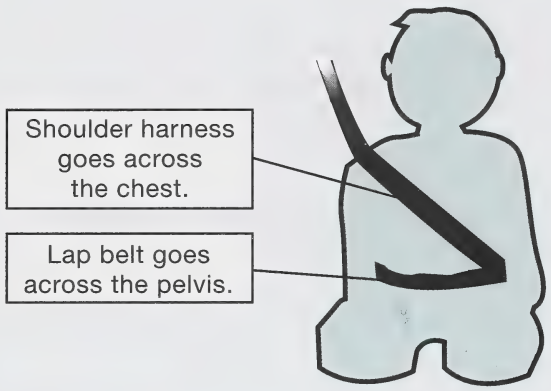
1.



2. a. **Textbook questions 2 to 6 of "Understanding Key Ideas," p. 302**

2. The lap belt is too dangerous for front-seat occupants because their upper bodies still can move forward, striking the windshield or dashboard.

3.



b. Rules for seat belt use include the following:

- Keep the lap belt and shoulder harness snug against your body.
- Keep the lap belt and shoulder harness in proper position across the pelvis and chest. Do not put the shoulder harness under your arm.

4. Safety technologies work to lower forces on occupants of vehicles by lengthening the time it takes for their bodies to stop (increasing the impulse).

5. Seat belts are attached to the frame rather than the seat because seats may move in a collision.

6. Because forces are so extreme in an accident, you could not use your arms to hold back your body from injury. Also, the times involved in collisions are often too fast for you to react.

b. **Textbook questions 7 and 8 of "Developing Skills," pp. 302 and 303**

7. a. The graph shows levels of seat belt use in three provinces—Newfoundland, Manitoba, and Alberta over the years 1980–1990.

b. Seat belt legislation was likely introduced in Newfoundland in 1982, in Manitoba in 1984, and in Alberta in 1988. These are the years when seat belt use rose dramatically in these provinces.

8. a. The graph reports crash-fatality rates for 0–14 year-olds and 15–19 year-olds per 100 000 people in Canada.

   b. The number of fatalities of the 15–19 age group between 1980 and 1990 dropped about 22 per 100 000.

   c. The number of fatalities of the 0–14 age group between 1980 and 1990 dropped about 3 per 100 000.

   d. The number of fatalities of the 0–14 age group between 1990 and 1996 dropped about 2 per 100 000.

   e. The increased use of infant seats, child seats, and seat belts was likely the reason for reduced fatalities between 1990 and 1996.

c. **Textbook questions 11 and 13 of "Problem Solving/Applying," p. 303**

11. A force strong enough to hold an 80-kg occupant would likely throw a 40-kg occupant backwards.

13. The windshield will pop out if an occupant strikes it, reducing the force of hitting the windshield and reducing extreme head injuries.

d. **Textbook question 15 of "Critical Thinking," p. 303**

15. Wider webbing will spread the forces in a collision more evenly across the pelvis and chest, reducing injuries.

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74 PhotoDisc Collection/Getty Images
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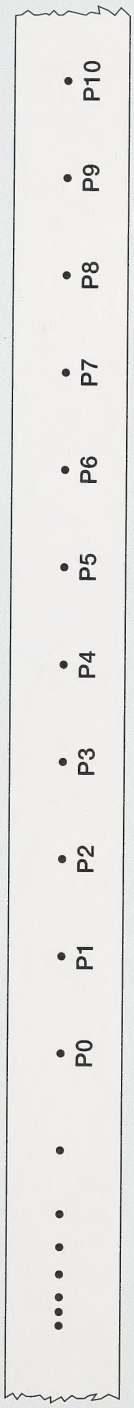
85 PhotoDisc Collection/Getty Images
86 PhotoDisc Collection/Getty Images
87 **main:** Digital Vision/Getty Images
background: EyeWire Collection/Getty Images (burst in top right corner); PhotoDisc Collection/Getty Images (all remaining photos)

Ticker Tape for Graphing Motion



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